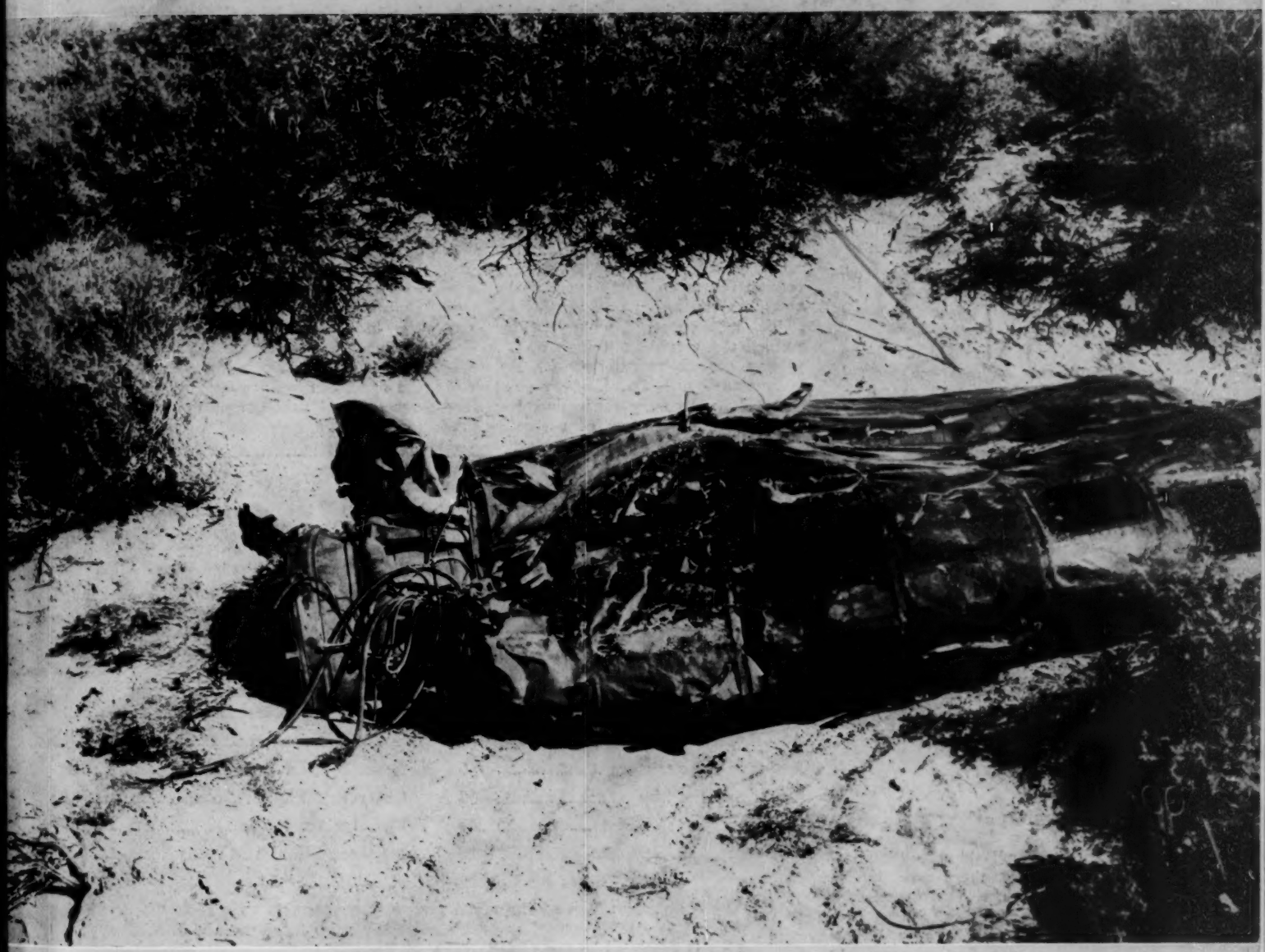
JAN 30 1947

Sky and TELESCOPE



Fallen V-2 rocke

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Vol. VI, No. 4
FEBRUARY, 1947
Whole Number 64
25 cents

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In This Issue:

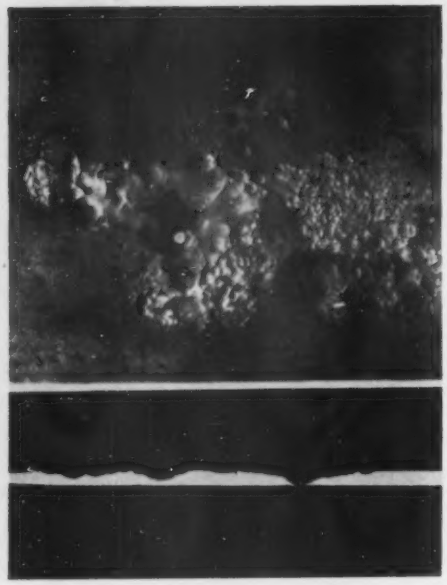
Solar Spectroscopy at High Altitudes

The Optical Glass Industry Past and Present — II

Depths of Space

American Astronomers Report

Northern and Southern Star Charts



Apparent blisters on a mild steel pipe which are actually corrosion pits, as is shown by the section below. This illustration, which had been furnished to Dr. Hudson by A. Preece, is from the "Journal" of the Optical Society of America.

LETTER TO THE EDITOR

Sir:

Not very long ago, your columns carried an interesting mention and discussion of the curious "reversal effect" evident in enlarged photographs of the moon's surface, whereby, under certain conditions —objective or subjective—those parts of the surface in relief appeared as depressions and vice versa. As evidencing the same phenomenon, I enclose a picture from a recent number of **Life** magazine, showing footprints in sand.

In this picture I can effect the reversal almost at will, and without difficulty, though I found it almost impossible at times to reverse the moon pictures, and when I had once got them reversed, they persistently stayed reversed, and I sometimes could not get them back again till the next day. This leads me to believe that the phenomenon is subjective, and dependent to a large degree on the question of whether the observer's eye is acute or temporarily fatigued, though it is probable that reversal is more readily effected with some pictures than with others.

ARTHUR BALDWIN
Charlottesville, Va.

Editorial comment: The page is from **Life** for September 2, 1946, page 111. When we opened Mr. Baldwin's letter and looked at the picture, there was the inversion in the footprints. On second look it disappeared and we haven't been able to bring it back since. Perhaps it was our distraction at not finding page 113 enclosed as well!

Almost simultaneously we came across an interesting note on page 492 of Vol. 36 of the **Journal** of the Optical Society of America entitled, "Longitudinal Inversion of Optical Images — Subjective or Objective?" It is a short discussion by Douglas Rennie Hudson, of the University of Leeds, England, who refers in turn to a note by Dr. Paul Kirkpatrick in the **American Journal of Physics** for June, 1945. The latter reported that the image of a rough surface like a brick wall, when focused in a telescope, appeared to show depressions instead of the protruding lumps actually existing.

Dr. Hudson finds a similar problem in microscopic examination of metal specimens, and says that when the elementary student starts high-power microscopy, he invariably finds great difficulty in deciding whether a blob in the field is protruding or recessive. In such cases a safe rule seems to be that a depression has a white spot in the center. Differential focusing is also helpful, but at powers of 1,000 or 2,000 times, the trouble still exists.

In a picture of hollow stone querns used for prehistoric gold mining in Nubia accompanying Dr. Hudson's note, the inversion first seen is removed, as he suggests, by turning the page upside down. (This, too, occurred when we first examined the picture, although now the inversion occurs irregularly with the page in any position.) Dr. Hudson points out that this looks very subjective, but then adds a second picture of corrosion pits on a steel pipe. The photograph, with vertical illumination, shows the pits as bubbles and there seems no way to "invert" them to give the correct impression.

The inversion of lunar crater photographs and other astronomical subjects was first discussed in **Sky and Telescope** in a letter from Julio C. Ortiz, of Havana, Cuba. This was in December, 1943, Whole Number 26, page 8. Further comments are in 27, 19; 28, 2; and 29, 19.

In the October issue (page 615) of the **Journal** of the Optical Society of America has appeared another note entitled "Axial Image Inversion," by Gordon L. Walls, of the department of psychology, University of Rochester. He believes the inversion phenomenon is purely subjective, and points out, "a photograph of a human face will refuse to 'invert' axially when turned upside down, no matter how the camera subject was lighted, because the observer's mind would reject the idea that any face could embody a concave nose, brow, and cheeks." This seems to fit in with our experience with the footprints in the sand, but we are still mystified about our original problem of the inversion of lunar craters. ED.

Sky and TELESCOPE

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FEBRUARY, 1947

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COVER: The shattered body of the V-2 rocket fired on October 10th after it had fallen from an altitude of over 100 miles to the New Mexico desert. Fortunately, the fin bearing the spectrograph had broken off and settled to earth more gently. (See page 3.)

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Stars for February 24

BACK COVER: A portion of the moon near last quarter, from a Lick Observatory photograph taken with the 36-inch refractor by J. H. Moore and J. F. Chappell. This is Plate XI in the series. (See In Focus.)

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SOLAR SPECTROSCOPY AT HIGH ALTITUDES

By CHARLES V. STRAIN

Naval Research Laboratory, Office of Naval Research

AT WHITE SANDS Proving Ground captured German V-2 rockets are currently being used in studies of the upper atmosphere. Several successful flights have been made and many different types of experiments have been carried out by different agencies engaged in a general program of upper atmosphere research. The actively participating organizations are the Naval Research Laboratory, Anacostia, D. C.; the Applied Physics Laboratory, Silver Spring, Md.; Princeton University; and the Army Air Forces through the University of Michigan and the Watson Laboratories in Cambridge, Mass.

One of the various projects being pursued by the Naval Research Laboratory is the measurement of solar radiation received at high altitudes. The entire upper atmosphere program is under the general direction of E. H. Krause, while the research on solar spectroscopy specifically has been carried out to date under the co-operative direction of R. Tousey and the author.

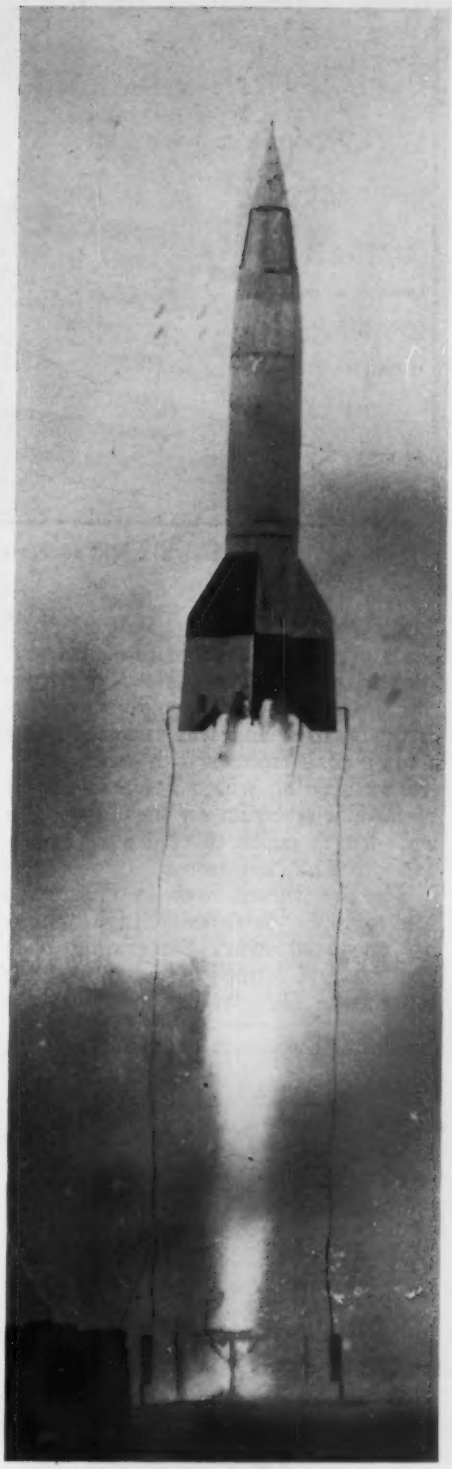
The principal advantage of the V-2 rocket as a means for exploring the upper atmosphere is unquestionably the fact that the missile can reach altitudes in excess of 160 kilometers, where estimates of the pressure run as low as 3×10^{-9} atmospheres. Presumably, absorption of solar radiation penetrating the earth's atmosphere to this altitude is negligible, at least to wave lengths as short as 1000 angstroms, and there is good opportunity for making significant advances in solar spectroscopy.

There are, to be sure, disadvantages which partially offset the main advantage in the use of a rocket in conducting experiments. For one thing, the flight is of short duration. The longest flight to date lasted for something on the order of nine minutes, and only about one half of this time was spent above 50 kilometers. The necessity for rapid, carefully timed experiments is plain. Furthermore, any instrumental installation in the V-2 is limited in space. Also, the fact that the V-2 sometimes rolls and tumbles during flight causes difficulties, especially in solar spectroscopy experiments for which proper orientation of the spectrograph is desirable.

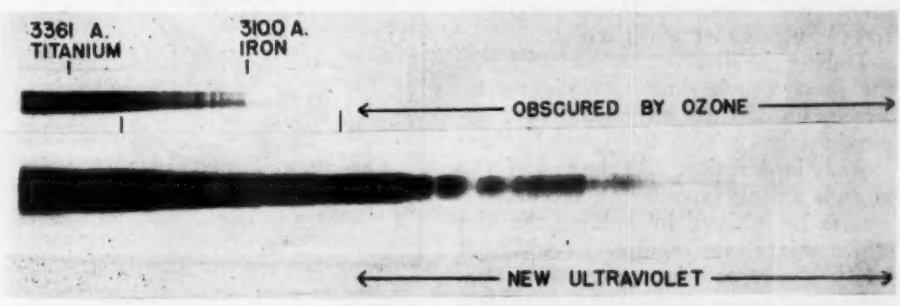
There is an additional problem connected with the use of a V-2 for solar spectroscopy, and it is characteristic of many experiments which cannot use radio methods for returning information to the ground. This is the fact that the film bearing the latent spectrograms must be recovered from the missile wreckage after the flight. The V-2 frequently returns to the earth with a velocity of about 4,000 feet per second. In one such case the rocket struck in sandy ground and dug a crater some 80 feet in diameter and 40 feet deep. Badly mangled pieces of the rocket were found in or around the crater, but the total weight of all recovered fragments hardly exceeded one per cent of the original weight of the rocket, and nothing of any significance was found.

As a result of this experience it was concluded that special methods of film recovery had to be devised. That used successfully on October 10th employed an artificially caused air burst of the missile to separate the warhead from the after part. The actual missile breakup occurred at a height of about 35 kilometers. The streamlining of the rocket was completely destroyed, and the various parts struck the ground at considerably reduced velocities. (See the front cover.) The spectrograph was almost entirely undamaged; in fact, the sole effect of its impact with the ground was a slight dent in the housing.

The spectrograph used on October 10th was designed at the Naval Research Laboratory especially for use in the V-2. The spectrograph employed a concave grating on a Rowland mount.



A V-2 rocket at the start of its flight, trailing the antennae for the telemetering of cosmic-ray, meteorological, and other data back to receiving stations on the ground.



Astronomers and physicists may now study a region in the sun's ultraviolet spectrum hitherto unobservable. The upper spectrogram was taken at an altitude of one mile, the lower one 35 miles above the earth's surface.

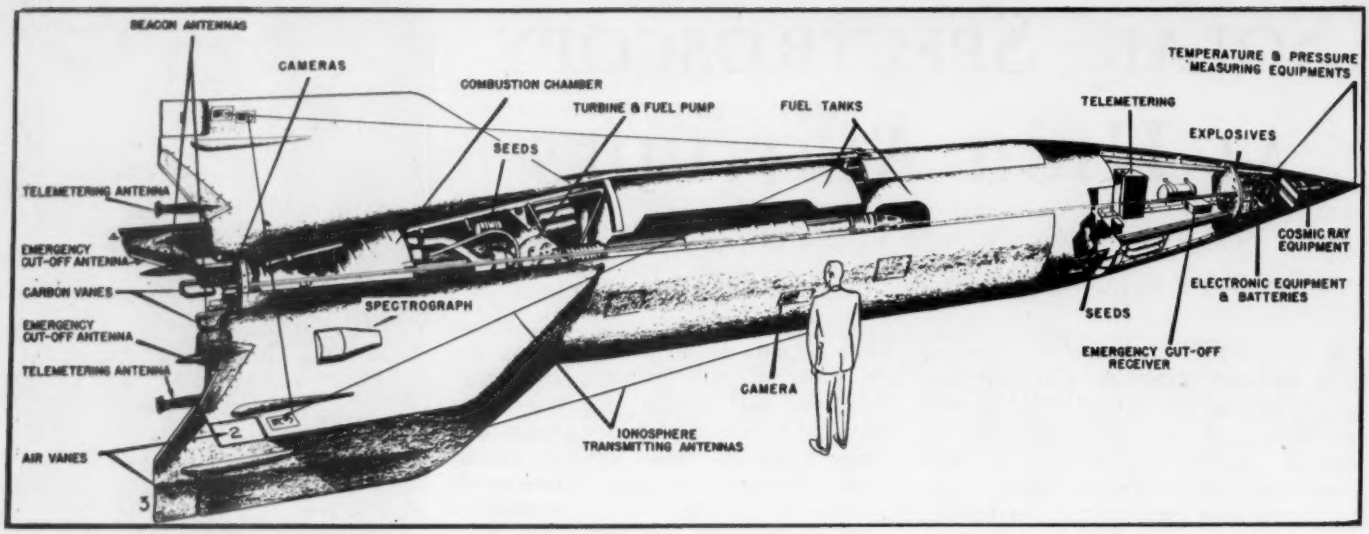


Diagram of a V-2 rocket equipped for upper atmosphere study. Note the spectrograph in the fin.

Sunlight incident on one of the spherical beads of lithium fluoride formed a real image just behind the bead. Light from this image passed through a motor-driven shutter and was reflected from a small plane mirror to a concave diffraction grating where it was dispersed to form a spectrum on the film. The wave-length region covered was roughly 1100 to 3400 angstroms.

The instrument was in effect two spectrographs combined. Light entering one bead struck the grating from one side and formed a spectrum at the top of the film, while light from the other bead struck the grating from the opposite side and formed a spectrum at the bottom. The use of two beads in this fashion doubled the instrument's angle of vision, and partially nullified the effect of roll, pitch, and yaw in the unstabilized portion of the trajectory after fuel burnout.

This is the specially designed spectrograph which was installed in the fin of the October 10th rocket. Note the lithium fluoride spherical bead at the center of the picture; the film cases and moving mechanism are at the bottom. The grating is near the top.

The lithium fluoride beads were used to focus as much light as possible into the spectrum for any value of angle between the bead axis and the incident rays of the sun. The more conventional method of a diffusing surface in front of a slit was not as satisfactory as the bead scheme. The use of the bead did, however, give rise to some displacement of the spectrum on the film when the angle between the direction of the sun's rays and that of the bead axis changed.

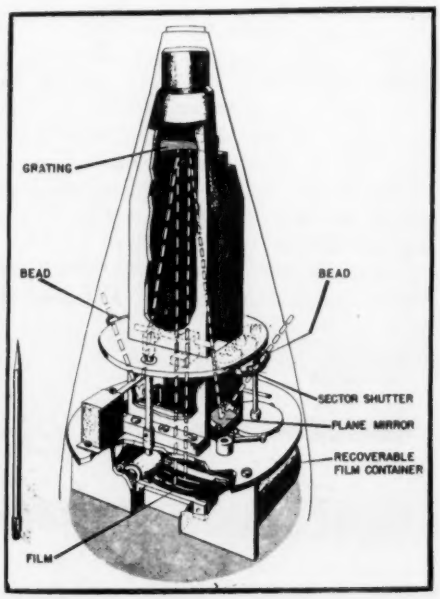
The concave grating was ruled by Johns Hopkins University on an aluminum-surfaced glass blank. It had a radius of curvature of 40 centimeters and was ruled over an area three by four centimeters with 15,000 lines per inch. A light ruling was used since this was expected to give the best results in the ultraviolet. The first-order spectrum was employed to avoid confusion with higher orders.

The spectra were formed on 35-millimeter film held along the Rowland circle by guides. The film, which was advanced automatically between exposures, was Eastman Kodak emulsion 103-O, ultraviolet sensitized.

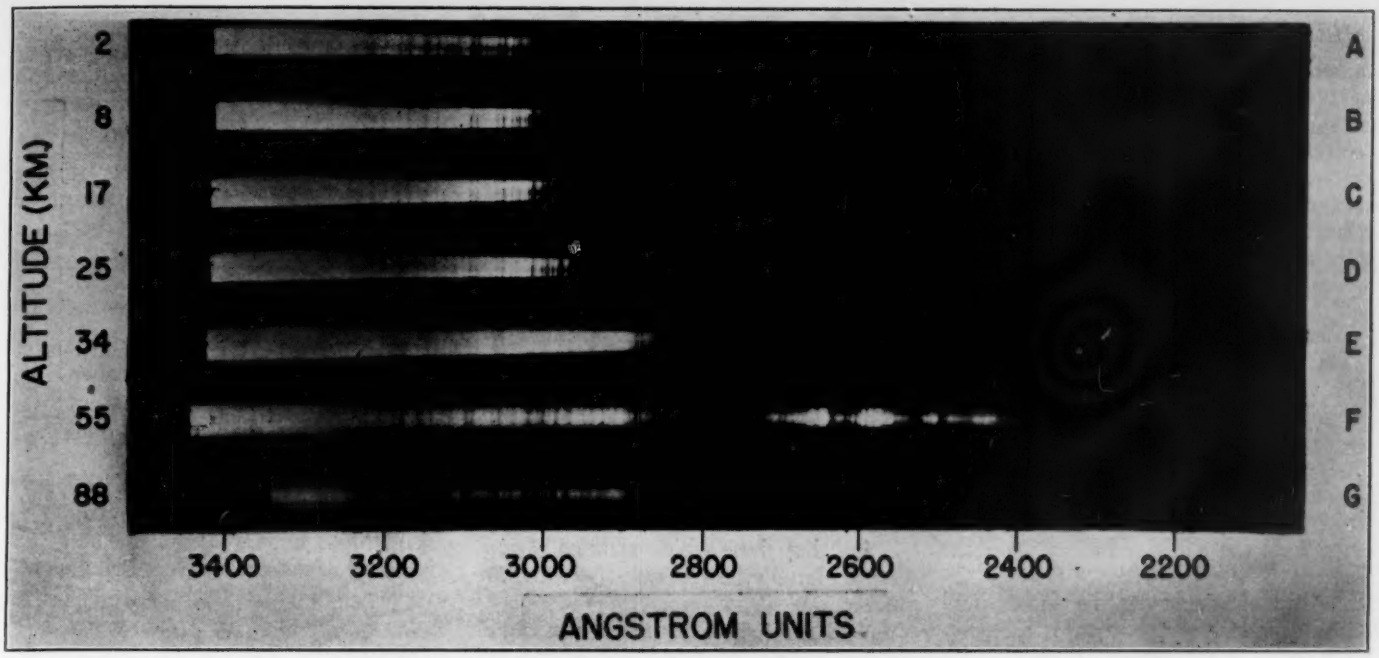
During the first 150 seconds of flight, the spectrograph shutters made successive cycles of three exposures, each approximately 1/10, 6/10, and three seconds in duration. At the end of 150 seconds a long exposure of 100 seconds was to be initiated by holding the film still. Since the shutters could not easily be stopped in an open position, they were to be allowed to rotate during this time, so that actually the effective exposure was only 55 seconds instead of 100 seconds. Following the long exposure the film was released and rolled rapidly into an armored film container.

The shorter exposures were expected to be adequate for photographing wave lengths 3400 to about 2000, and to allow a more detailed study of atmospheric absorption than could be obtained using longer exposures. The 55-second exposure was timed to begin just before the top of the trajectory was reached and to end shortly after it was passed. During this period, the effect of absorption by the earth's atmosphere should be negligible, and it was hoped that the long exposure would intensify the spectrogram at the shorter wave lengths.

It appeared probable that the 55-second exposure near the top of the trajectory would also result in considerable blackening of the film due to scattered



Compare this diagram of the operation of the spectrograph with the photograph on the left showing the actual instrument.



The first spectrograms ever procured above the ozone layer of the earth's atmosphere.

light. Most of this light would be from the more intense part of the solar spectrum above 2000 angstrom units. To counter this effect, one of the plane mirrors was clear, unsilvered crystalline quartz. The reflectivity of such a mirror at around 1200 is nearly as great as that of an aluminized mirror, so that there was little loss in speed in this region. On the other hand, the reflectivity for wave lengths greater than 2000 is no more than 1/15 that of aluminum; hence scattered light was greatly reduced in intensity. The rear of the quartz mirror was roughened and blackened with India ink to avoid undesired back-surface reflection. To provide speed for the short exposures during the early part of the trajectory the other plane mirror was aluminized.

The motors which were used to operate the shutters and to move the film were powered by the main 24-volt storage battery in the warhead of the rocket. To prevent accidental operation prior to takeoff of the rocket, the spectrograph motors were protected by two switches connected in series. One was a manual safety switch closed shortly before takeoff. The other was an automatic switch, mounted in the tail of the rocket, which was closed automatically when the V-2 left the launching stand. A micro-switch was installed which opened momentarily each time the film advanced. The pulse thus generated was transmitted to ground stations by the use of telemetering, and recorded. Later correlation of these pulses with trajectory data enabled one to determine the altitudes at which the various spectrograms were taken.

Experience prior to October 10th seemed to indicate that chances of recovering equipment installed in the after portion of the rocket were better than those of recovering equipment from the warhead. As a result, for the flight made on October 10th, the spectrograph was installed in the tail of the missile, in Fin No. 2, which was pointed west at launching. The installation was made so that the entrance apertures were on either side of the fin, one pointed south and the other north. This arrangement insured that sunlight would enter the instrument from the south during the early part of the flight when the rocket was stabilized.

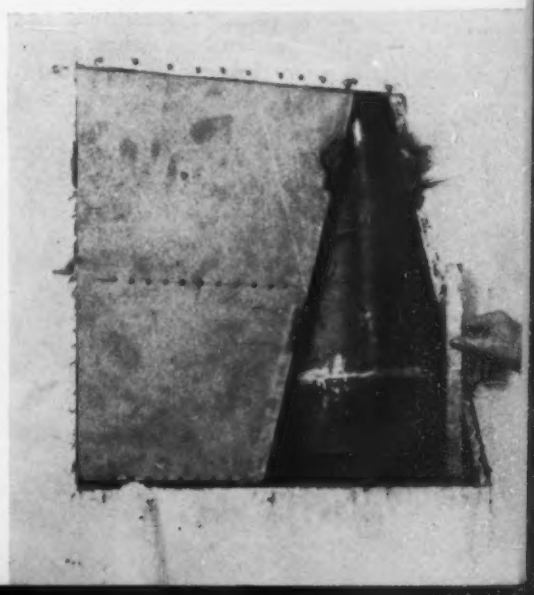
The spectrograph was mounted in a well in the fin, and fairing shields were placed around the spectrograph to give as smooth an outside surface as possible. To balance the drag caused by the blister thus formed, a similar blister was placed on the opposite fin.

To obtain spectra at wave lengths shorter than the cutoff for air (1840 angstroms), it was necessary to evacuate the spectrograph during flight. For this purpose, an air duct with a set of black optical baffles was provided, which connected the spectrograph to the interior of the fin. Evacuation of the fin was supposed to have been accomplished by means of a vent already furnished, but the evacuation speed proved to be inadequate.

The rocket was successfully launched on October 10th. The spectrograph was found on October 16th and returned to Washington two days later. During the flight, after the warhead had been separated from the rocket by explosive charges, the rocket more or less tore apart. The fin holding the spectrograph came away from the main body of the rocket and was found essentially intact. As mentioned before, the instrument was hardly damaged and, in fact, was in perfect operating condition except for a slight pitting of the lithium fluoride beads. This, it is believed, was due to exposure in the desert.

The film was developed at the Naval Photographic Center, in Washington, using a large 35-millimeter motion-picture film processing machine, which gives the most uniform development possible along the length of the film. The speed with which the film was run through the machine was adjusted so that the development obtained was approximately equivalent to a five-minute tray development in D-19.

An inspection of the film showed that during a part of the flight the instrument advanced two frames of film per exposure instead of one. Consequently, the film had been used up by the time



How the spectrograph was placed in a housing in the fin of the rocket. The fairing covers are still to be put in place. Note the opening for the entrance of sunlight.

the rocket reached an altitude of approximately 107 kilometers. For this reason the 55-second exposure was not obtained. The best solar spectrogram was made at approximately 55 kilometers altitude, for the highest solar spectrogram obtained at 88 kilometers was weak, the sun being far off the spectrograph axis. Between this altitude and 107 kilometers the rocket had rolled so far that no sunlight entered the instrument.

The spectra shown here were all taken with exposures of 3.6 seconds. The cutoff at the long wave-length end of each spectrum was determined by the optical properties of the spectrograph. The variation in the cutoff position resulted from the motion of the spectrum which occurred when the angle of incidence of the sun's radiation upon the spectrograph changed.

As can be seen from the illustration, there is a gradual extension of the spectrum into the ultraviolet as the altitude increased. At 25 kilometers the spectrum was photographed to 2925 angstroms. The spectrum taken at 34 kilometers extends on the negative clearly to 2650; at that height there was enough ozone above the instrument to obscure the central region of the Hartley band (2550 angstroms). However, some radiation was observed at shorter wave lengths between the Hartley band and the region of oxygen absorption, for the negative shows measurable blackening from about 2260 to 2100; this blackening was faint and is lost in reproduction. At 55 kilometers the instrument was well enough out of the ozone layer to obtain a photograph of the spectrum throughout the Hartley band. As mentioned, the spectrum at 88 kilometers is faint because the rocket had turned the instrument away from the direct rays of the sun.

Analysis of data obtained on this flight is now under way. Spectra taken with the instrument in the laboratory are being analyzed in order to obtain an intensity calibration of the instrument. Successive exposures are being compared in order to determine the absorption occurring in the earth's atmosphere. Solar absorption lines are being identified and the intensity of the continuous solar spectrum measured. In addition to this analysis work, other installations are being planned for future rockets in order to improve and extend the data obtained so far.

The success enjoyed in the program to date has resulted from assistance received from many groups. Thanks are due to U. S. Army Ordnance for making the use of V-2 rockets possible and for aid in installations. Thanks are also due to the Johns Hopkins University for discussion of the problem and for ruling the gratings used, and to Baird Associates for constructing the spectrograph in a very short time.

Amateur Astronomers

Amateur Astronomers League Organizes

BIRTHDAY of the Amateur Astronomers League was November 15, 1946, when the 10th ratification was received by the Committee on Permanent Organization. But more ratifications quickly followed, so that by December 31st the list of member societies had reached 22, and in addition to this, the members of the American Association of Variable Star Observers voted to join the League.

A letter containing the list of members has been sent by James B. Rothschild to all other known groups, suggesting that those which planned to join before January 15th take part in the nomination of members for the temporary council. On that date the nominations were to be closed, and ballots for the election of the temporary council sent to all the members. As soon as the council is formed, officers will be elected and the League will be incorporated, in accordance with its by-laws.

The report here is necessarily written several weeks before its publication, so the following list includes only those groups for which ratification had been received by the end of December:

Association of Amateur Observers, New York, N. Y.
George Gregory Memorial Observatory, Paul Revere Boys Club, Jersey City, N. J.
Detroit Astronomical Society, Detroit, Mich.
Portland Amateur Telescope Makers and Observers, Inc., Portland, Ore.
Popular Astronomy Club, Moline, Ill.
A. T. M. Astronomical Club of San Diego, San Diego, Cal.
National Capital Astronomers, Washington, D. C.
Eastbay Astronomical Association, Oakland, Cal.
Kalamazoo Amateur Astronomical Association, Kalamazoo, Mich.
Astronomical Society of Maine, Portland, Me.
Beaver County Amateur Astronomers Association, Baden, Pa.
Joliet Astronomical Society, Joliet, Ill.
Milwaukee Astronomical Society, Milwaukee, Wis.
Louisville Astronomical Society, Louisville, Ky.
Northwest Detroit Astronomical Association, Detroit, Mich.
Owensboro Astronomical Club, Owensboro, Ky.
New Haven Amateur Astronomical Society, New Haven, Conn.
Bond Astronomical Club, Cambridge, Mass.
Burnham Astronomical Society, Chicago, Ill.
Madison Astronomical Society, Madison, Wis.
Portland Astronomical Society, Portland, Ore.
Amateur Astronomers Association of Pittsburgh, Pittsburgh, Pa.

Those groups wishing further information concerning membership in the Amateur Astronomers League may write James B. Rothschild, Box 281, Wharton, N. J.

Skyscrapers To View Eclipse

Brown University and the Skyscrapers, Rhode Island group of amateur astronomers, are jointly sponsoring an eclipse expedition to Araxa, Brazil, under the leadership of Professor Charles H. Smiley, director of Ladd Observatory. The expedition, leaving Providence about April 1st, will journey by ship to Rio de Janeiro, thence by rail to Araxa, in the state of Minas Geraes, about 300 miles northwest of Rio.

Visual and photographic observations of the outer corona and the zodiacal light in the vicinity of the sun will be made, and the contacts will be timed. The party will stay in Brazil a few weeks after the eclipse to make other astronomical observations.

SIRIUS

Oh Sirius, blue, majestic,
When through the winter skies
You trail Orion,
Whose glory you might well reflect;
I gaze at you in rapture
Knowing that your glory is your own.
The closest, brightest of the starry horde
To those of us beneath the Northern Cross,
Oh may your beauty rest each weary soul
Which seeking rest, beholds you
And forgets.

MARGARET STUART

Pittsburgh Amateur Dies

On December 8th, Harry J. Collins, treasurer of the Amateur Astronomers Association of Pittsburgh, died suddenly. On the 13th, the society would have celebrated his 63rd birthday at the Russell W. Porter Day meeting. Mr. Collins was treasurer for three years, and, since its inception, a member of the telescope committee, whose function it is to operate the 10-inch siderostat telescope at the Buhl Planetarium for the benefit of the public.

Edwin S. Hider, 476 Longridge St., Pittsburgh 16, succeeds Mr. Collins as treasurer.

Washington Amateurs Active

Star Dust, bulletin of the National Capital Astronomers, indicates that the program of this society is rapidly expanding, and that junior astronomers are being encouraged. Recently, 77 variable star and three occultation observations were reported by junior members of the group. Morgan Cilley, observation chairman, is also planning

observations for the regular members.

Members took turns working with Bureau of Standards technicians counting Geminid meteors visually and by radar on December 11, 12, and 13. The first two nights were cloudy, so after an inspection of the equipment, the visual observers watched the oscilloscope screen for meteor deflections. Friday night, however, the observers outstripped the radar by counting 137 meteors in three hours in a prescribed area of the sky.

Yakima and Tacoma Societies

From *The Observer,* bulletin of the Yakima Amateur Astronomers, we learn news of this society and of its neighbor at Tacoma, Wash. The 10th annual banquet of the Yakima group brought out 35 members and guests, perhaps the largest attendance at any meeting of the society in recent years. Sound motion pictures were shown.

Edward J. Newman, editor of *The Observer,* was re-elected president of the Yakima society, with Orris Thompson as vice-president, Arlene Benson as secretary, and Mrs. Walter Hoge as treasurer.

Tacoma amateurs were invited to the dinner at Yakima, but weather conditions prevented their attendance. The Tacoma amateur astronomers have resumed their meetings which were suspended during the war. Mrs. Lenora McCarty is president; R. C. Elliott, vice-president; Roy Atkinson, financial secretary; Dorothy Nicholson, recording secretary.

Memorial to Junior Astronomer

At the annual jubilee meeting of the Junior Astronomy Club in New York next May, an outstanding member of the group will receive the first annual Seymour Schinasi Memorial award, established in memory of a former Junior Astronomy Club president who died in World War II. The first award will be a 3½-inch Skyscope reflector, provided by the Junior Astronomy Club Alumni Association.

Plans are now being made to set up a trust fund to insure the making of the award each year. Already a substantial contribution has been offered by the Schinasi family. The award will be made each year to a junior astronomer on the basis of his activities in the club, his contributions to amateur astronomy, and his personal ability and accomplishments in fields related to JAC activities.

The Junior Astronomy Club office is open on Monday, Wednesday, Friday, and Saturday of each week, from about 12 noon to 5:00 p.m. For information, visit the office in person in Room B-49 of the Roosevelt Memorial, American Museum of Natural History, or telephone ENdicott 2-8500, Ext. 289, during these hours.

THIS MONTH'S MEETINGS

Chicago: "The Earth in Motion and the Solar Family" is the title of a sound motion picture to be shown on Tuesday, February 11th, at 8:00 p.m., at the meeting of the Burnham Astronomical Society, Chicago Academy of Sciences Auditorium.

Cleveland: Dr. Donald A. MacRae, of the Warner and Swasey Observatory, will speak on "The Motion of Stars" at the February 7th meeting of the Cleveland Astronomical Society. The meeting is at 8:00 p.m., at the observatory.

On February 27th and 28th, Warner and Swasey Observatory will hold open nights, beginning at 7:45 p.m. The lecture subject will be "Beyond the Milky Way." Reservations may be made by calling GArfield 6680.

Detroit: "Exploding Stars" will be discussed by Dr. Dean B. McLaughlin, of the University of Michigan Observatory, at the February 9th meeting of the Detroit Astronomical Society, 3:00 p.m., Wayne University.

Geneva, Ill.: At the February 18th meeting of the Fox Valley Astronomical Society, William Siekman will talk on "Astronomical Photography." The meeting is at 8:00 p.m. in the Geneva City Hall.

Indianapolis: Walter Wilkins will describe the Link Observatory of Brooklyn, Ind., at the meeting of the Indiana Astronomical Society on Sunday, February 2nd, 2:15 p.m., at Odeon Hall.

Madison: "Revelations of the Spectroscope" is the title of a lecture by W. R. Binney before the Madison Astronomical Society, on Wednesday evening, February 12th, at Washburn Observatory.

New York City: At the meeting of the Amateur Astronomers Association on Wednesday, February 5th, 8:00 p.m., at the American Museum of Natural History, Dr. Paul R. Heyl, of the National Bureau of Standards, will speak on "The Speed of Light."

The Junior Astronomy Club speaker on Friday, February 28th, will be selected by the annual Junior Competition among members of the club.

Philadelphia: On February 14th, Robert Fleischer, Rensselaer Polytechnic Institute, will lecture before the Rittenhouse Astronomical Society on "Probing the Milky Way." The meeting will be at 8:00 p.m., Morgan Physics Laboratory, University of Pennsylvania.

Pittsburgh: The lecture scheduled for January 10th was postponed to Friday, February 14th, when the Amateur Astronomers Association of Pittsburgh will hear a talk on "Atomic Power," by John E. Roblee, of the Westinghouse Electric Corporation.

Washington, D. C.: Rev. Francis J. Heyden, S. J., of Georgetown University, will be lecturer at the meeting of the National Capital Astronomers on Saturday, February 1st, at 8:00 p.m. in the Commerce Department Auditorium. Father Heyden's topic will be "Looking Through the Milky Way."

ELECTRONICS NAVIGATION

At the December 3rd meeting of the Boston section of the Institute of Navigation, Dr. J. A. Pierce, of Harvard University, discussed the general characteristics of the various electronic systems now available for long-range navigation. There are six types.

Gee operates at about 50 megacycles now, with a maximum range of 400 miles at 30,000 feet, but considerably less range at lower altitudes.

High-frequency direction finding at 10 megacycles employs sky waves which are inherently unpredictable, with errors of two to five degrees possible; it is practically obsolete now.

Loran operates at two megacycles, with a sea-water range of 700 nautical miles by day and 1,400 miles at night, the latter with some decrease in accuracy. Errors in fixes run from a mile to perhaps five miles.

Sonne (Consol) operates at 300 kilocycles, day range 700 to 800 miles, night range 1,000 to 1,200 miles with sky waves. It has all the errors of the direction finder; a good system, but not good enough for the future.

Low-frequency loran operates at 140-200 kilocycles. In daytime, its range is 2,400 miles at best, 1,200 at worst; at night, the 4,000-5,000-mile range is not useful because of geometrical error. Usually this system is good to within 10 miles, and it is a promising aid to polar navigation.

Decca operates at 100 kilocycles, with "high discrimination but no judgment." It is very accurate for short range, useful for 200 to 300 miles, bad for long range.

MILITARY PLANES FOR COSMIC RAYS

The aerial guns of the Army's B-29 bombers are being replaced by Geiger counters, cloud chambers, and other scientific equipment at the Naval Ordnance Test Station at Inyokern, Cal., thus converting the planes into airborne cosmic-ray laboratories. Under the direction of Dr. Carl D. Anderson, California Institute of Technology, discoverer of the positron, the planes will collect data from altitudes up to 40,000 feet, according to Science Service. Last summer, previous use of this type of bomber was made under the joint auspices of the Army Air Forces, the National Geographic Society, and the Bartol Research Foundation, in flights between the Canadian border and Peru. The B-29's are expected to obtain some 1,200 photographs daily during an average of five flight hours per day.

For data at higher altitudes, even beyond 100 miles, the necessarily short-duration flights of the V-2 rockets are being successfully utilized.

NEWS NOTES

By Dorrit Hoffleit

SEARCH FOR LUNAR ATMOSPHERE

Recently, we called attention to a method proposed by M. A. R. Khan for the detection of a lunar atmosphere by means of observations of aurorae on the moon (page 6, September, 1946). Now Dr. G. Herzberg, of Yerkes Observatory, proposes another method which he believes to be more critical, namely, fluorescence radiation on the bright side of the moon. In *Popular Astronomy* he writes:

"Such fluorescence will produce a corona around the moon in much the same way that a head is formed by the gases emanating from the nucleus of a comet. Indeed cometary material in the form of meteors is constantly being deposited on the moon and on being heated by the sun it should give off gases similar to those in a comet."

The reason such fluorescence has not yet been successfully observed is that stray reflected light from our own atmosphere obliterates it. Here the coronagraph can be of assistance for the same reasons that it is necessary for solar coronal work. Preparations are therefore under way for getting the desired observations at the Climax station of Harvard Observatory and the University of Colorado.

FAILURE OF V-2 METEORS

The experiments with artificially produced meteors designed for the December 17th launching of a V-2 rocket at White Sands, N. M., were a failure. For some unknown reason the mechanism which was to fire the man-made meteorites failed to function. As yet no plans for a second attempt have been formulated.

TURTLE AND DREAMBOAT USE CELESTIAL NAVIGATION

Bausch and Lomb bubble sextants were essential instruments in guiding both the *Truculent Turtle* in its recent flight from Australia to Ohio and the *Pacusan Dreamboat* from Hawaii to Egypt. This was partly a result of the necessity for the elimination of much radar and all loran equipment in order to make room for the fuel so necessary on these record-breaking flights. This was revealed at a recent joint meeting of the Institute of Navigation and the Institute of Aeronautical Sciences in Washington.

As the *Turtle* crossed the Pacific in its 11,250-mile non-stop flight, four-star fixes were taken at night and sun positions by day. Prior to the pre-dawn takeoff, over a ton of radar gear was removed from the ship.

The *Dreamboat* Superfort started its flight with a record load of 13,000 gallons of gasoline and, like the *Turtle*, carried no loran equipment on the flight of 10,300 miles. Of special importance was celestial navigation over the region of the magnetic pole, particularly with the present uncertainty existing as to the location of the pole itself and the consequent behavior of the magnetic compasses.

SWEDISH ECLIPSE EXPEDITIONS

Dr. Bertil Lindblad, director of the Stockholm Observatory, reported on his recent visit to America that Swedish astronomers and geodesists are planning to observe the eclipse of May 20th from stations near Montes Claros, Brazil, and in the Gold Coast region of South Africa. Astronomers from Sweden's three most famous observatories, Stockholm, Uppsala, and Lund, will participate in programs like those carried out in Sweden during the eclipse of July 9, 1945 (see *Sky and Telescope*, January, 1945, page 8).

Motion pictures will be taken both directly and for flash spectra, principally for the determination of geodetic positions by the Swedish Coast and Geodetic Survey. The lunar parallax, the topography of the moon, and the polarization of the solar corona will be investigated as well.

PANNEKOEK AND ZANSTRA

Nature announces the retirement of A. Pannekoek and the appointment of H. Zanstra as director of the Astronomical Institute of Amsterdam. As its first director, Professor Pannekoek has built up the reputation of the institute as a center for research in stellar physics and stellar statistics. His investigations of the distribution of *B*-type stars, ionization theory, the theory of model stellar atmospheres, and recent work on the spectra of Cepheids are well known.

Professor Zanstra, Great Britain's first Radcliffe traveling fellow in astronomy, has been associated with the Hamburg-Bergedorf Observatory. He is especially recognized for his work on gaseous nebulae, having provided the accepted quantitative theory of their luminosity, and investigated the dynamics of radiation pressure in gaseous and planetary nebulae. In recent years he has done notable work in solar physics. Consequently, it is foreseen that he will maintain the high reputation that Pannekoek has established for the Astronomical Institute of Amsterdam.

OPTICAL SOCIETY TO MEET IN NEW YORK CITY

The winter meeting of the Optical Society of America will be held at the Hotel Pennsylvania in New York City on February 20, 21, and 22, 1947. The program committee planned to devote a large portion of the Thursday sessions to contributed papers on infrared analysis. On Friday, new methods of radiometry and their applications will be stressed, and there will be papers on spectrochemical analysis; simultaneous sessions on Friday will cover general optics. Vision and color will be discussed on Saturday. The society dinner will take place Friday evening, February 21st.

The Optical Society meeting is open to non-members of the organization, who may secure copies of the program from the secretary, Professor Arthur C. Hardy, Massachusetts Institute of Technology, Cambridge 39, Mass.

MORE ATOM SMASHERS

The world's most powerful atom smasher, the University of California's 184-inch cyclotron, has been completed, according to Science Service. Built under the direction of Dr. E. O. Lawrence, the new frequency-modulated cyclotron is now undergoing tests to co-ordinate the various parts of the complicated apparatus. The new cyclotron can generate heavy hydrogen at 200 million electron volts and helium nuclei (alpha particles) at 400 million electron volts.

Meanwhile, also at Berkeley, Cal., a 300-million-volt synchrotron is being built under the direction of Dr. Edwin M. McMillan, and is scheduled to be completed early this year. And a model of a linear accelerator proposed by Dr. Luis W. Alvarez, and believed capable of billion-volt accelerations, is under construction.

NEXT SUNSPOT MAXIMUM

In a brief summary in *Scientific Monthly*, Dr. Harlan T. Stetson, of the Cosmic Terrestrial Research Laboratory at Needham, Mass., discusses the uncertainties in the prediction of the exact time of the maximum frequency of sunspot occurrences. While the average cycle is about 11 years, individual cycles range from nine to 19 years. Numerous predictions for the coming maximum, based on past behavior and plausible theories, have been made. Dr. Stetson's prediction is 1948.2, while Dr. John Q. Stewart, Princeton University Observatory, sets the time as 1948.0. Earlier still is Swiss astronomer M. Waldmeier, who predicts 1947.6 in the *Journal of Terrestrial Magnetism*, but C. N. Anderson, of the Bell Telephone Laboratories, does not expect the maximum to be reached until 1951.

Just wait and see!

The Optical Glass Industry
Past and Present

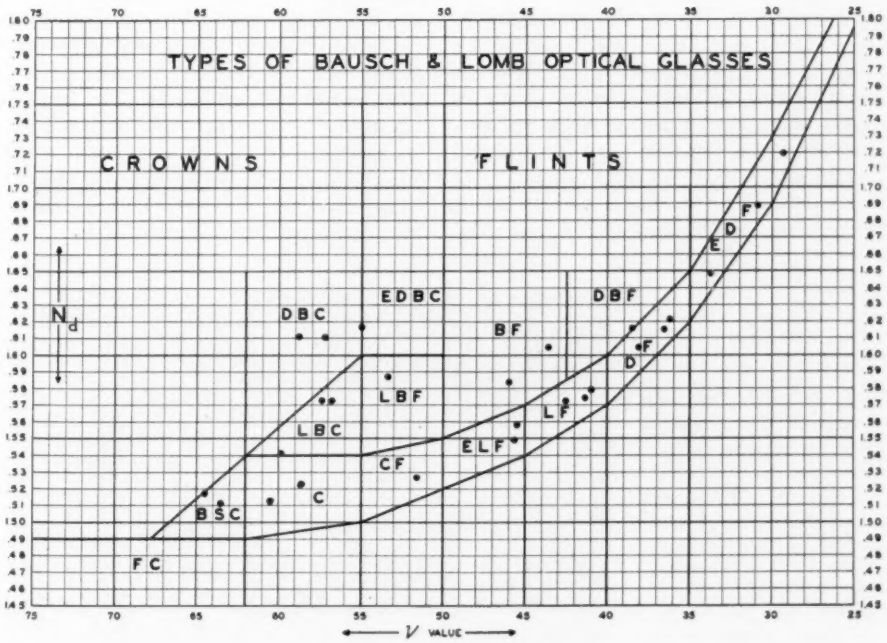
By Francis W. Glaze, *Technologist, National Bureau of Standards*

PART II

Casting the 70-inch disk of optical glass. The molten glass is flowing down the metal trough from the pot into the combined mold and annealing furnace.

At the National Bureau of Standards 28 different types of optical glass have been produced with indices of refraction ranging from 1.511 to 1.754 and with nu-values from 64.5 to 27.7. The nu-value is the reciprocal of the dispersive power of the glass. There are three wave lengths that are especially important in the measurement of refractive index: the sodium D line, 5893 angstroms, in the central region of the visible spectrum; the hydrogen C line (H-alpha), 6563 angstroms, in the red; and the hydrogen F line, 4862 angstroms, in the blue. When the mean refractive index is given, that for the sodium D line is meant. For each type of glass there is a definite relationship between the indices of refraction for the three spectral lines mentioned. The reciprocal of the dispersive power, instead of the dispersive power itself, is used in order to avoid fractional values. A high nu-value represents a low dispersive power and a low nu-value a high dispersive power.

For glasses of index of refraction less than about 1.555, the allowable tolerance is 0.001 of index either way; for those above 1.555 it is 0.0015. The allowable tolerances for the nu-value vary somewhat. For nu-values above approximately 50.0, it is 0.4 to 0.5 either way, depending on the type of glass. Below 50.0 it is 0.3. The light absorption of all types of optical glass except dense and extra dense flints and dense barium crowns must not exceed one per cent per centimeter of light path measured in white light (generally it is only half of that value). For dense and extra dense flints and dense barium crowns, two per cent is allowed, although it practically never exceeds 0.8 per cent.



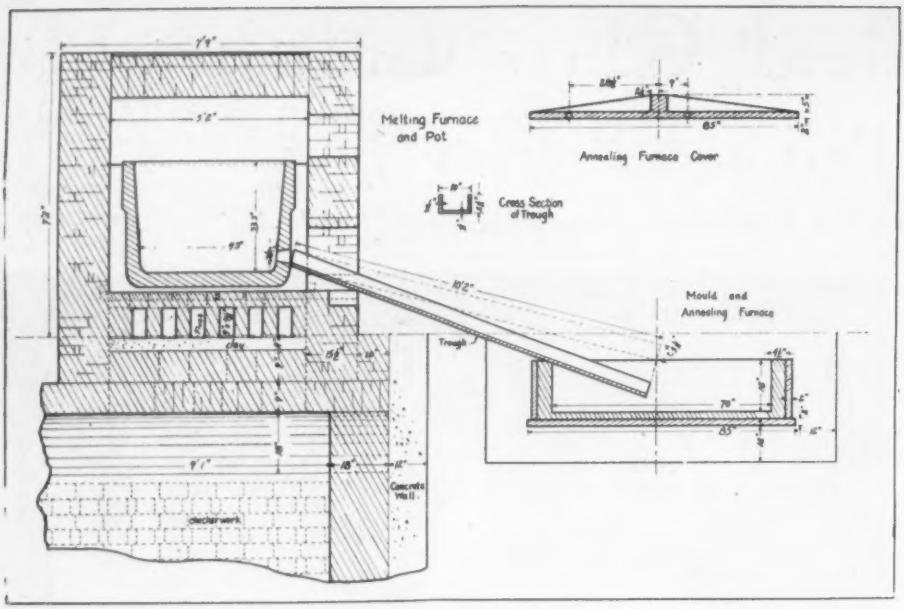
This chart shows the relation of index and reciprocal dispersion of the common types of glass. Most glasses lie near a curve in which dispersion increases with index; glasses far off this curve are especially useful to the designers of optical systems. Diagram, courtesy Bausch & Lomb Optical Company.

Freedom from seeds or bubbles is desirable for the sake of appearance, but is not necessary except in reticles or windows and other elements in a focal plane. Appearance, therefore, poses quite a problem for the glassmaker because the barium glasses so necessary in photographic objectives today are especially difficult to make seed-free.

As can be seen from the foregoing, the production of glass for the ordinary types of optical instruments is fraught with many difficulties. And when the glassmaker is called upon to produce lenses or mirrors for astronomical telescopes, his problems are increased manyfold. It will be the purpose of the remainder of this paper to show how these difficulties were overcome, first at the National Bureau of Standards and, later, at the Corning Glass Works.

Although there have been some notable large lens blanks made in Europe, the most famous being the 40-inch refractor of the Yerkes Observatory at Williams Bay, Wis., the larger telescopes are all of the reflecting type.

The manufacture of a large lens



The essential features of the equipment for the 70-inch disk, shown in use on the preceding page.

necessitates a single large chunk of perfect optical glass which must then be brought to the required shape by heating and softening it in a ceramic mold of proper size. Such large chunks of glass are extremely difficult to obtain, usually requiring many melts of glass. Upon examination of the resultant lens, it may be found to be unsatisfactory, and all the work has to be done again. Nor are the difficulties over even then. To complete the lens requires the accurate grinding and polishing of two faces. For a mirror for a reflecting telescope, only one face of the disk has to be ground and polished. Also, the glass for the disk may contain considerable seed and striae unless they are on the surface and interfere with the figuring of the mirror. Because of this simplification, the largest telescopes are reflectors.

Except for two disks, one 23 inches in diameter made in 1889 and one 60 inches in diameter made in 1895, the manufacture of telescope mirror blanks was also considered a European monopoly until 1926. In that year, Ohio Wesleyan University asked the National Bureau of Standards to make a blank 70 inches in diameter. Such a disk, assuming the thickness to be one sixth the diameter, would be 11 inches thick and weigh about 4,000 pounds.

The type of glass decided on was an ordinary borosilicate crown. The batch was melted in a pot holding approximately 5,000 pounds of glass, near the bottom of which was a hole stoppered with a water-cooled metal plug. After the batch had completely melted, stirring was started and continued for six hours, after which the temperature was reduced from 1,400° to 1,350° C. While the pot was filled, current was applied to the heating elements of the combination mold-annealing furnace.

When arrangements were completed for tapping the pot, the water-cooled plug was removed and the glass flowed by means of a trough into the mold-annealing furnace. After practically all the glass was in the mold, the trough was removed and the top of the annealing furnace placed in position.

Thirty-three hours after pouring, the insulation over the top of the annealing furnace had been built up to the 12 inches that covered the rest of the furnace. The loss of heat became so slow then that no current was necessary for four days; it was not until eight days after casting that the average temperature of the furnace reached 600° C. During the next two months, the temperature of the furnace was gradually reduced to the annealing temperature of 461° C., which was then maintained for 41 days.

Assuming now that the disk was free from strain, it was still necessary to cool it so slowly that no great amount of strain would be present at the end of the process. Although the data of L. H. Adams and E. W. Williamson indicated that an initial cooling rate of 2.33° C. per day and a maximum rate of 60° C. per day would be permissible, it was decided to use an initial rate of about 1° C. per day and a maximum rate of not over 10° C. (preferably 6° C.). The reason for such conservatism was that Adams' and Williamson's findings were based on the annealing of much smaller pieces of glass, and that the validity of extrapolations from data obtained on small pieces to the case of a much larger piece was questionable.

The cooled disk was removed from the mold and the insulating bricks stripped off. Before examining it for strain, the bottom surface was ground with carborundum and water to remove the adherent particles of brick. Placed on edge, with the ground surface coated with mineral oil, the disk was examined for residual strain by projecting a divergent beam of polarized light against one surface and examining it through a Nicol prism from the opposite side. The interference figure was found to be very symmetrical, with its intersection in the center of the disk. The maximum strain detected produced a retardation equivalent to about six millimicrons per centimeter of thickness, well within the maximum strain permissible in optical glass used for optical instruments of highest precision.

All that remained was to cut the eight-inch hole for the Cassegrainian mounting. This was accomplished in about 70 working hours and without any unforeseen difficulties. So ended an operation that took over 15 months: six months and better for making and air-drying the pot; about 15 days for burning the pot, melting, and pouring; 7½ months for annealing and cooling; and for strain inspection and cutting the hole, spare time as it became available. And this does not include the time necessary for making and drying the mold for the pot.

The task presented to the Corning Glass Works by the California Institute of Technology in 1931 was to make a mirror blank of low-expansion boro-

The 70-inch disk was examined prior to shipment by Dr. G. K. Burgess, then director of the Bureau of Standards, and Professor C. C. Crump, former director of the Perkins Observatory. The 8-inch core is resting on the surface of the disk.

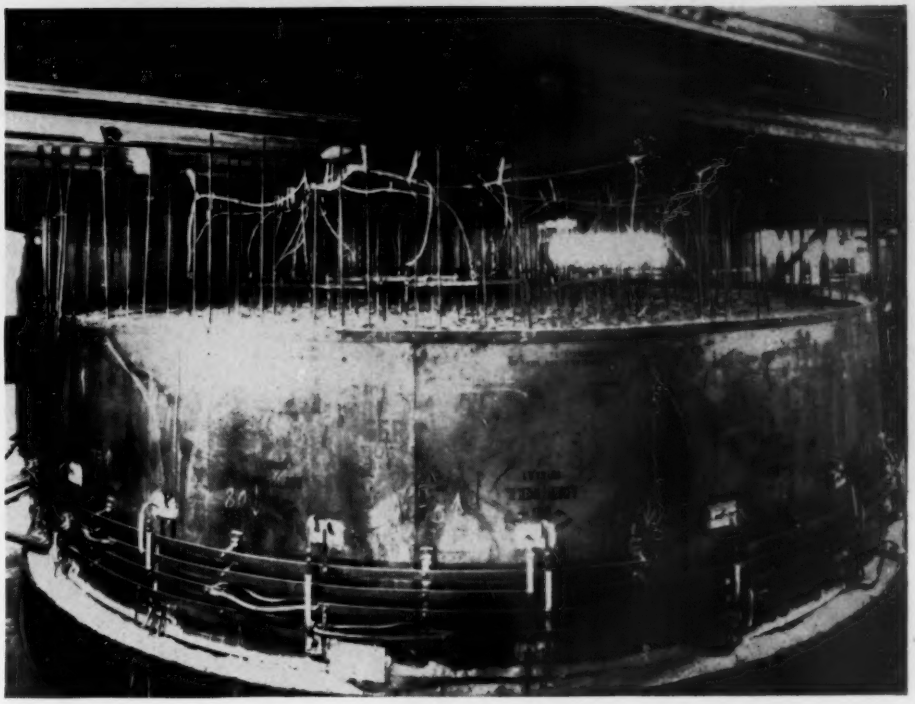
silicate glass and of sufficient size to produce a telescope disk 201 inches in diameter of materially less weight than the 40 tons which would result from the customary thickness of one sixth the diameter. As an aid to proving the feasibility of whatever program might be adopted for manufacture, the Observatory Council of the California Institute of Technology ordered two small disks 30 and 60 inches in diameter, respectively. The design of these was to be similar to that of the large blank to demonstrate the practicability of reducing the weight without sacrificing rigidity and precision of the figure in the finished mirror. Also, a disk 120 inches in diameter, of similar design, was desired for use as an optical flat with which the 200-inch disk could be tested by the opticians during the figuring process. Thus, along with the task of making the large disk, there were furnished steppingstones by which fulfillment could be reached.

For this purpose, tank melting was the logical choice. It was felt that the composition from one pot to another would be subject to more variation than would be found in glass from a single filling of a large day tank. The glass employed required a higher melting temperature (1,580° C.) than was obtainable with available pot furnaces. Also, ladling equipment was less costly than installing means for pouring the glass from pots. Ladling permits one to rake the surface of the bath when necessary to free it of objectionable scum or floating stones before filling the ladle. It also affords an opportunity to inspect the quality of the glass prior to pouring it into the mold.

The mold was complicated because of the ribbed structure required in the lower portion of the finished disk. The cores were made of high-temperature insulating brick of standard size laid with high-temperature cement, and they were anchored to the iron bedplate of the mold by means of a heat-resisting alloy. The anchors were provided with adequate air cooling. This maintained the temperature safely below that at which the tensile strength of the anchors could not withstand the buoyant force of about 300 pounds on the largest cores for the seven hours necessary for the casting operation.

The pouring oven over the mold had three ladling holes and was heated with natural gas to keep the glass sufficiently fluid to flow to all parts of the mold. The three ladles used in casting had a capacity of 750 pounds each and the ladle skins were returned to the tank in order to conserve glass.

After pouring was completed on December 2, 1934, the mold was moved on rails to the annealing position by means of a hand-operated drum and cable. The entire upper portion of the annealing furnace, including top and side walls, was suspended like the pouring oven and was electrically heated. The lower portion of the annealing furnace was built on the screw hoist beneath the mold. The two portions telescoped for some distance as the disk was raised into the annealing position.



The exterior of the annealing kiln for the 200-inch disk. Corning Glass Works photo.

During the soaking, or constant-temperature period of annealing, which required about 50 days, controllers automatically maintained the temperature at the desired value. For the 200-inch disk, 26 inches in thickness, the cooling rate was maintained at 0.72° C. per day from the initial temperature of 500° C. until 300° C. was reached. Below the latter value, a more rapid cooling rate was possible. About 10 months were required to reach room temperature.

To some extent, the task of making these disks was lessened by the choice of a Pyrex-type of glass. Its coefficient of expansion, only 2.5×10^{-6} cm. per °C. per 1 cm. length against 8.5×10^{-6} cm. per °C. for ordinary borosilicate crown, greatly reduced cooling stresses and shortened annealing times. On the other hand, it added materially to the difficulty of melting and working. The successful fabrication of large disks cannot be ascribed wholly to the use of low-expansion glass. The same methods of manufacture outlined here would produce disks of ordinary crown glass with greater ease of melting and casting. The time required to anneal such glass, however, would be increased nearly fourfold, and greater demands would be made on the temperature control equipment to maintain the corresponding slower rate of cooling. Mirror blanks of ordinary crown would be heavier and, because of the higher coefficient of expansion, would require a much longer time for grinding and polishing. This is expected to take a total of three years for the 200-inch disk.

From the foregoing it can be seen that there is no need for astronomers of the United States to go to Europe to fill their needs for optical glass. There is in this country the "know how" to fill their wants, fantastic though they may seem. The field has been thoroughly explored. Practically no money or time need be spent in experimental work to develop a satisfactory method of procedure.

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AAAS ELECTS PRESIDENT

The new president of the American Association for the Advancement of Science is Dr. Harlow Shapley, director of Harvard College Observatory. Dr. Kirtley F. Mather, professor of geology at Harvard University, and Dr. George A. Baitsell, professor of biology at Yale University, were named to the council of the association for four-year terms.

A portion of the Milky Way in the constellation of Monoceros. Harvard Observatory photograph.

DEPTHS OF SPACE

By Robert R. Coles

Hayden Planetarium

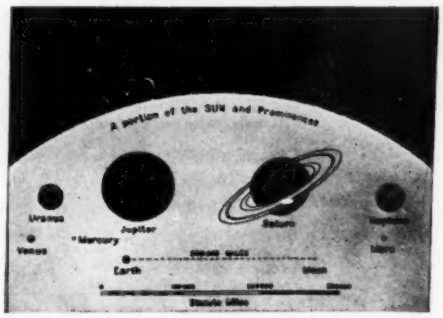
IN CONSIDERING the sky picture as viewed from the earth we might think of the depths of space as comprised of four regions. These may be designated as the foreground, the middleground, the background, and the extreme background. The distances to these regions range from a few miles for the nearer foreground, to millions of light-years in the extreme background. We will consider each of these regions separately and in its relation to the perspective as observed from the earth.

1. The *foreground* of our sky picture is the earth's atmosphere, in which phenomena of an astronomical nature are observed and which affects the apparent position and appearance of those objects that lie in the regions beyond, frequently hiding them entirely from our view.

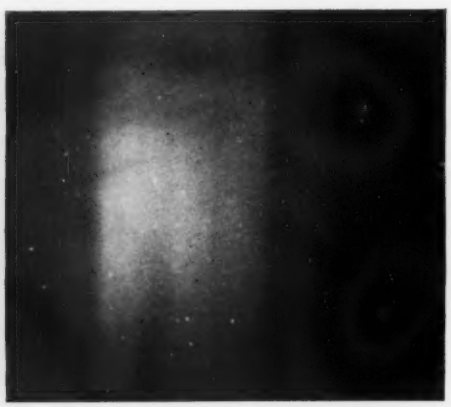
The depth of the atmosphere has been determined by Stoermer as being at least 600 miles. This is the height at which he has photographed the aurora. Meteors have been measured at heights exceeding 100 miles. While both the aurora and meteors belong in the foreground of the sky picture, the latter are really visitors from the realms beyond. These come into the atmosphere from the middleground, where they travel in swarms about the sun. Meteors are members of the solar system and are known in many cases to be the remains of disintegrating comets.

In one sense the atmosphere is the realm of the meteorologist, for it is in the lowest level, known as the troposphere, that our weather is generated. But since the ocean of air in which we live so largely affects the appearance of what lies in the deeper realms it is of more than casual interest to the astronomer. Indeed, this shimmering veil distorts the sky picture in a variety of ways. Because of the atmosphere's continual state of agitation, the stars are seen to twinkle like sparkling jewels in the celestial sphere. When the sun or moon hangs low over the horizon, the lower levels of the atmosphere tend to filter out the shorter wave lengths of their light, making them appear orange or red. Clouds and moisture in the air reflect and refract sunlight to produce the spectacular pageantry of dawn and twilight.

The refraction of light by the atmosphere also has important effects on the apparent positions and sizes of the heavenly bodies. It causes all of them to appear higher in the heavens than they are really, with the result that we may observe the sun, moon, planets, and stars before they have actually risen and also after they have set. Because the amount of refraction increases with decreasing altitude, the sun and moon often appear distorted. The amount of the distortion depends on many factors, and at the recent meeting of the American Astronomical Society, Dr. Charles H. Smiley, of Ladd Observatory, reported on a series of observations of the sun he has been making to determine the variations in the value of refraction within five degrees of the horizon. Most navigation books warn the navigator to avoid taking sights of celestial bodies at such low altitudes, but the increasing necessity for daylight navigation in arctic regions makes a study of the problem of immediate importance. For aerial navigation, the value of the refraction at negative altitudes (where the real horizon is several degrees below the astronomical horizon because of the height of the plane) is also an important consideration.



Principal members of the solar system — the middleground — are here shown to scale against a portion of the sun.



These simultaneous pictures of auroral rays 500 miles high — in the sunlit portion of the atmosphere — were taken in 1939 by Carl Stoermer from two stations in Norway 100 miles apart.

Then there is the blue sky, because of which we cannot generally observe the stars by day. Its cause is found in the billions upon billions of air molecules and dust particles in the atmosphere which scatter the short wave lengths of light — blue and violet — to all parts of the sky. Because the telescope concentrates light from point sources, bright stars are telescopically visible through the blue. Venus may frequently be seen by day with the

naked eye. Bright stars are also observed during a total solar eclipse, and some observers have reported seeing some of the brighter stars by day from the summits of lofty mountains where the air is less dense and there is less dust.

Certain phenomena, such as solar and lunar halos, also belong to the foreground of the sky picture and in the borderland of meteorology and astronomy.

2. In the *middleground* of the sky picture are the various bodies belonging to the solar system. These include the sun, moon, planets, satellites, asteroids, comets, and meteors. Except for the last, the distances to these range from an average of 239,000 miles for the moon to about 3 2/3 billion miles for Pluto, the farthest planet that is known. Far beyond Pluto are the long-period comets, which are definite members of the sun's family and are therefore confined to the middleground of the sky picture.

These objects of the middleground are apparently the most energetic actors in the sky drama. Their motions, both real and apparent, add very much to the color and vitality of the scene. The apparent eastward motion of the sun along the ecliptic and the phases of the moon change the scene each night and season. The complex motion of the planets against the background of fixed stars is one of the most interesting sights for the beginner. Surely, without the presence of these near neighbors of the middleground much of the fascination would be missing from the panorama of the heavens.

3. The so-called fixed stars that form the familiar constellation patterns make up the *background* region of our sky picture. In addition to the stars that we can see individually with the naked eye are those that make up the Milky Way. While these are reckoned in the billions, they are mostly so remote that they cannot be seen individually without telescopic aid. Other objects that belong to this background region are the various star clusters and the bright and dark nebulae.

Together these objects make up the mosaic against which the members of the solar system play their role. The nearest of the stars are hundreds of thousands of times the sun's distance from the earth. The Milky Way galaxy, to which these background objects belong, is estimated to be more-or-less discoidal in shape and some 100,000 light-years in diameter. The solar system seems to be about 30,000 light-years from the center of the galaxy, which is located among or beyond the star clouds in the constellation of Sagittarius.

Remote as this background is, it is near compared with the region which comprises the outposts of the heavens as observed from the earth.

4. The *extreme background* is made up of the vast population of other galaxies beyond the farthest reaches of the Milky Way. So far as northern observers are concerned, only one of these is easily within naked-eye visibility — the Great Nebula in Andromeda. But this galaxy is indeed one of the most interesting objects in the entire sky. Although appearing as an indistinct patch of light to the unaided eye, long-exposure photographs reveal it as a huge universe of billions of suns similar to the stars that populate our own galaxy. The Andromeda system is considered by most astronomers to be a fair image of our own Milky Way galaxy.

The distance to Messier 31, as the galaxy in Andromeda is called, is of the order of 750,000 light-years, which is determined from the magnitudes and periods of some of the Cepheid variable stars it contains. The diameter of the system is probably about 60,000 light-years. This is smaller than our galaxy but still of respectable proportions, and there is evidence that the actual extent of M31 may be greater than is readily observed on the best photographs.

So far as the non-telescopic observer is concerned, the Andromeda galaxy represents the farthest outpost of the visible universe, but for the penetrating eye of the telescope it is merely next door to our own system of stars. It forms part of the local group of a dozen or so objects, including the spiral in Triangulum and the Magellanic Clouds. Photographs record millions of additional galaxies making up the visible universe. The extreme depths to which the great 100-inch telescope at Mount Wilson has penetrated are estimated as some 500 million light-years. This, therefore, we may conclude as representing the outposts of the heavens as known today. But science advances so rapidly they will undoubtedly be passed in the near future.

In the constellation of Andromeda there are other galaxies of note in addition to the famous M31. This is NGC 891, an edgewise spiral. Mount Wilson photo.

In this composite Harvard photograph, the Milky Way is at the left and the Large and Small Magellanic Clouds are toward the center and the right.

Members and guests at the 76th meeting of the American Astronomical Society, at

AMERICAN ASTRON

Here are highlights of some papers presente American Astronomical Society, held at Cam 27-30, 1946. Further reports will be publishe month, and complete abstracts will appear i

General Notes on the Meeting

HENRY NORRIS RUSSELL, Princeton astronomer for the past 50 years, gave the first Henry Norris Russell lecture on Saturday evening, December 28th. His topic was "The Royal Road of Eclipses," and concerned principally the present state of our knowledge of eclipsing binary stars. Before the lecture, Dr. Russell was presented with an embossed scroll and the names of those who contributed to the Henry Norris Russell lecture fund. The amount of the fund, including a donation received just prior to the time of the first lecture, is now exactly $10,000, the income from which will be used to provide the annual lectureship.

On Sunday, at the society dinner, the Annie J. Cannon prize in astronomy was awarded to Dr. Emma Williams Vyssotsky, a member of the staff of the Leander McCormick Observatory, University of Virginia. Her husband, also an astronomer at McCormick Observatory, and a co-worker with Mrs. Vyssotsky on stellar spectra and the statistics of stellar motions and distances, accepted the prize in her absence. The award is made every three years to a woman for distinguished contributions to astronomy.

Friday and Monday sessions were held in Longfellow Hall, Radcliffe College, and the group photograph was taken in front of Agassiz at Radcliffe on Friday. The cold, fair weather which prevailed then turned during the night to snow, followed for two days by ice, sleet, and rain. Nevertheless, the trip to inspect the Oak Ridge station of Harvard Observatory was held on Sunday as scheduled, a special bus taking the visiting astronomers on the round trip of about 50 miles.

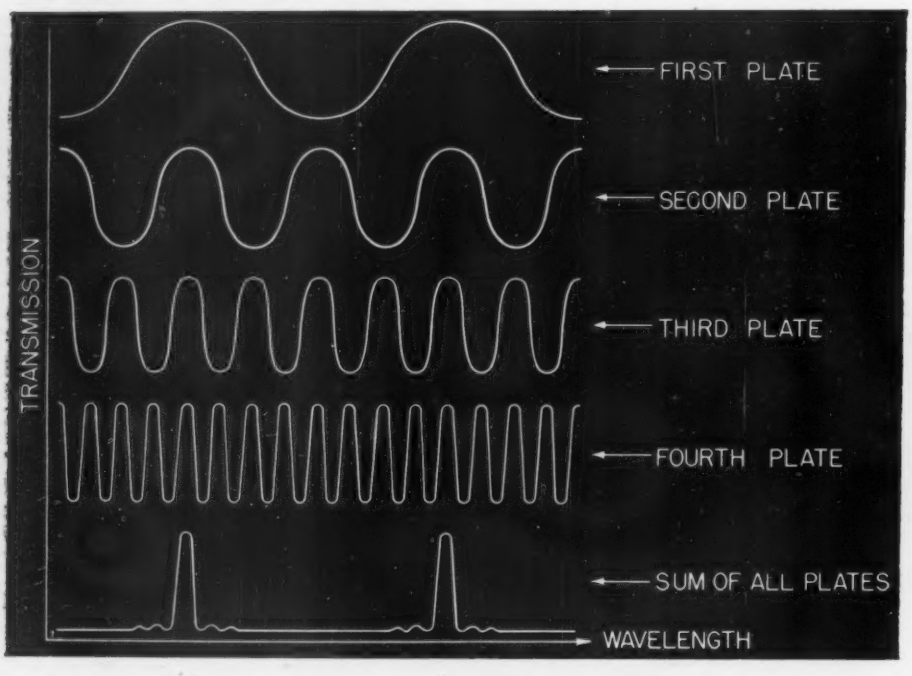
The Saturday morning symposium was held at the new Computational Laboratory building at Harvard, home of the new "Mark II" electronic calculating machine.

A reception was held at the Observatory residence by Dr. and Mrs. Harlow Shapley on Saturday afternoon, at which a large number of AAS members congregated for a social interlude.

Most of the sessions were heavily attended, with many scientists present from other sections of the American Association for the Advancement of Science which were meeting concurrently in Boston and Cambridge.

Retiring addresses were in order. On Friday, Dr. J. J. Nassau, of the Warner and Swasey Observatory, retiring vice-president of AAAS Section D, spoke on "Interstellar Absorption from Colors in Cygnus." A non-astronomical topic, "Goals of International Cooperation," was chosen by Dr. Shapley for his address as retiring president of the American Astronomical Society and Christmas lecturer of the Society of the Sigma Xi. This lecture was given on Sunday evening at Sanders Theater, Harvard University.

Upon registering for the meeting, members were given an illustrated 94-page booklet entitled, *Harvard College Observatory — The First Century*. This was published to celebrate the observatory's centennial, on the occasion of which this meeting of the AAS was held at Cambridge. In addition to the general papers on Sunday, 27 symposium papers were given, some of which will be abstracted in future issues of *Sky and Telescope*. The complete sympo-



The transmission of a four-element filter and its individual sections, showing how very narrow bands of light are transmitted, any one of which may be used. Diagram, courtesy Polaroid Corporation.

Society, at Cambridge, Mass., December 27, 1946. Photo by Ufford-Fleischer.

ONOMERS REPORT

s presented at the 76th meeting of the ld at Cambridge, Mass., on December be published in Sky and Telescope *next l appear in the* Astronomical Journal.

sium papers are to be published in a special Harvard Observatory centennial volume.

Tunable Monochromatic Filter

POLARIZATION FILTERS have been designed which have a transmission band only a fraction of an angstrom wide. As employed in the coronagraph by Lyot and others, these have consisted of "sandwiches" of quartz and polarizing material, so that the constructive interference of successive layers permits passage through the filter of light of very nearly only one wave length. To this arrangement, Dr. Bruce Billings, of the Polaroid Corporation, has added a series of plates of a crystal of high electro-optic coefficient. These crystals are so sensitive to changes in their electric condition that their optical passband can be shifted at will in less than 1/100,000 second. The crystals are made of ammonium dihydrogen phosphate, known as PN.

When the Billings filter is constructed and operated with a coronagraph to observe solar prominences expanding in the line of sight, the wave length in which observing is done can be shifted at will to match the motion of the prominence itself. From the Doppler shift in various parts of the prominence, its nature in three dimensions can be determined more accurately than heretofore possible. Present filters, fixed at certain wave lengths or broadened to pass wider regions of the spectrum than desirable, cannot obtain a completely detailed picture of how the solar streamers travel along the line of sight.

Coronal Absorption Line?

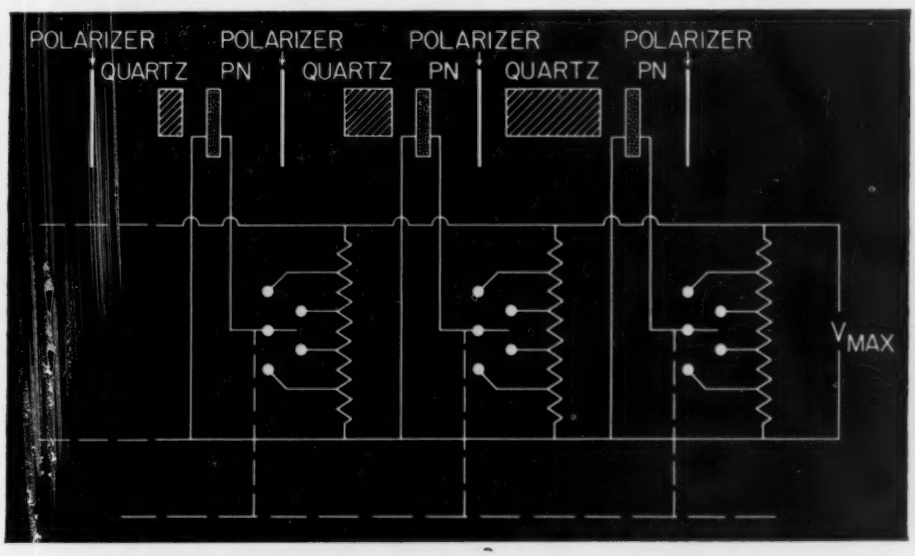
A BROAD, DIFFUSE absorption line at wave length 6374.45 has been found by University of Michigan astronomers in the spectrum of the solar disk on plates obtained with the McGregor spectrograph and the 70-foot tower telescope of the McMath-Hulbert Observatory. Its width has been estimated at 0.3 to 0.4 angstrom. The line is seen very faintly at the center of the disk, becoming strongly accentuated at the limb of the sun. It appears equally intense all around the limb and no significant variations in intensity or in wave length have been found. The appearance of the line and the closeness of its position to that of the red line in the spectrum of the sun's corona (given by Lyot as about 6374.51) suggest the possibility that the absorption line arises from atoms of Fe X (iron ionized nine times).

Dr. Leo Goldberg presented the paper for himself and his colleagues, Drs. Robert R. McMath and Orren C. Mohler, and pointed out that the present identification of the line is inconclusive. If the line is due to Fe X, however, its intensity and distribution around the limb appear to be such that a considerable abundance of Fe X must be present in the sun's chromosphere, whereas hitherto iron in this highly ionized state has been identified only in the solar corona. Its existence there, and that of other highly ionized atoms, corresponding to temperatures of hundreds of thousands of degrees, form one of the major mysteries of solar astronomy.

Aerial Eclipse Observations

OPERATION ECLIPSE was described by Dr. Peter M. Millman, now of the Dominion Observatory at Ottawa, in *Sky and Telescope* for September, 1945. The instruments and methods of observation in three R.C.A.F. planes at the eclipse of July 9, 1945, were described and some of the spectra and photographs obtained were reproduced. Dr. Millman reported at the meeting on the reduction of the spectro-

(Continued on page 20)



The scheme of the Billings tunable filter with its electrical control network. Diagram, courtesy Polaroid Corporation.

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Hayden, Planetarium Book Corner, New York 24, N. Y.

BOOKS AND THE SKY

STARCRAFT

William H. Barton, Jr., and **Joseph Maron Joseph**, Second Revised Edition, Whittlesey House, 1946. 250 pages. $2.75.

ALTHOUGH INTENDED primarily for high-school age, this book will find many enthusiastic readers among both older and younger groups. The key feature is the large number of astronomical activities for which complete directions are given, requiring only homemade or very inexpensive apparatus. It is thus an ideal book for one who likes to work on his hobby instead of merely reading about it or listening to lectures. It is highly recommendable to science teachers, boy scout leaders, nature study counselors, and others in similar positions.

The first chapter contains a description of the sky and the constellations in general terms, followed by constellation charts and mythology in the second chapter. A novel method is used to locate each constellation in the sky. Silhouetted figures with raised arms show the altitudes for different times of the year, and the azimuths are shown by the positions of the silhouettes around a compass rose. There is also the not new, but nonetheless important idea of listing features in each constellation to be seen with naked eye, opera glass, and small telescope, respectively. With each constellation chart is printed a picture of some noteworthy object in that area of the sky, taken with a large telescope at one of the big observatories. Charts of the whole sky are included for several times of year to tie the constellation charts together.

Chapter 3 contains directions and suggestions for making your own star charts, to shine by reflected light or illumination from behind, an indoor activity which pays big dividends in increased knowledge of the constellations. Meteors and their observations are next emphasized as an activity which can be great fun for individuals and groups of amateurs. The importance of this work by amateurs has been recently emphasized at the American Astronomical Society's symposium on the gaseous envelope of the earth. Another chapter treats of positional astronomy and navigation.

Construction details for an orrery, for sundials and star clocks, for a small reflecting telescope, are all included in this book. A dozen astronomical stereoscopic views are given in the next chapter, along with directions for making a viewer for about 25 cents. One chapter contains good directions for astronomical photography with very modest equipment. The volume concludes with one-page biographies of famous astronomers of the past.

A school child reading through **Starcraft** and working out the projects would painlessly learn many of the elements of astronomy, particularly with reference to the solar system. Perhaps it is difficult to carry the project method to sidereal astronomy and astrophysics, but in a future edition of this book it may be possible to include something on sunspot and variable star observing and recording, making models of eclipsing binary systems, and models or charts showing the relative sizes, shapes, and separations of clusters and galaxies.

Only one valid criticism may be made in reference to the star charts. The symbols indicating the relative magnitudes do not differ sufficiently in size, and as a result each chart does not seem to portray an easily recognizable configuration.

This book is a complete revision and extension of an earlier edition under the same title. Due to the death of the senior author, the revision was carried through by Mr. Joseph, who is to be congratulated on a fine piece of work.

ROBERT FLEISCHER
Rensselaer Polytechnic Institute

PRINCIPIA

Isaac Newton. A revision of Motte's translation by Florian Cajori, 2nd printing. University of California Press, Berkeley, 1946. 680 pages. $6.50.

ONE OF THE MOST valuable of Florian Cajori's contributions to the history of mathematics and science is his revision of Motte's translation of Sir Isaac Newton's **Principia.** This revision was first published in 1934, four years after Professor Cajori's death. The second printing in 1946 differs in only one respect that the reviewer has been able to detect: the printer's imprint has been changed from "Printed in the United States of America by Samuel T. Farquhar, University Printer," to "Printed by offset in the United States of America." This must be recognized as a matter of no small significance. It is not difficult to understand that in 1934 the publishers would have made a conservative estimate in deciding the number of copies to be printed; and the price of $10.00 was a bargain, considering the excellent typography, careful proofreading, and handsome binding. But the second printing is likewise an excellent offset job, even to the faithful reproduction of broken type and "dead lead" in the origi-

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nal volume (although the reviewer had difficulty in locating examples to check). Also reproduced, however, is at least one obsolete statement in the 44th note in the appendix regarding the existence of nine moons of Jupiter instead of 11. The binding is a sturdy, light brown buckram.

At the modest price of $6.50, this monumental work will now find a far greater circulation than ever before. This is within the range of simple gifts that are exchanged among friends, and within the means of anyone who prizes his library collection. No "commercial" is intended; but rather it is meant to emphasize the contrast between our present good fortune, due to technological advances in printing, and the situation which Cotes described in 1713 near the end of his preface to the second edition of the original **Principia:** "Since copies of the previous edition were very scarce and held at high prices...."

The Cajori translation received several reviews at the time of its first printing. After three centuries, a classical masterpiece scarcely needs reviewing any more than do successive reprintings of the Bible. And like the Bible, very few laymen will sit down and start to read it from cover to cover. But reading the **Principia** is an experience like a visit to a collection of old art treasures. Reading it can be enjoyed equally by one who is a mathematician and one who is not. And the experience is enhanced by the "tourists' guide" which Professor Cajori has contributed in the form of an appendix of 59 notes. These notes are interesting and informative of themselves, but they may also be used to bridge the wide chasm by which the uninitiated usually feel they are separated from such an imposing work as this. The ordinary, intelligent reader who has only an amateur interest in the subject matter may very well reverse the usual procedure by first reading the notes in the appendix one at a time, and then referring forward to the text to which each applies. This can be done with profit in small doses. Only a few doses will be sufficient to convince one of the thrill that comes with living, for a short time, with the frontiers of human knowledge of three centuries ago.

The most attractive part of the **Principia** to the writer is the portion in which Newton deals with comets. While Galileo had gained quite a bit of knowledge concerning falling bodies, and Kepler had discovered the laws of planetary motion from geometrical considerations, very little was previously known about comets except Tycho's observation that they were farther away than the moon. Newton resolved the riddle of comets, but not without some effort. After laying the groundwork, he comes to "Proposition XLI, From three given observations to determine the orbit of a comet moving in a parabola. This being a problem of very great difficulty, I tried many methods of resolving it . . . ." The students in an orbit class may be grateful to Newton for that consoling statement, but nowadays this problem is usually solved within a few hours after the three observations become available.

The example following this proposition is based on the comet of 1680. This section contains a description of the observations, the forerunner (or perhaps the original?) of the Harvard Announcement Cards. How many Americans realize that in the **Principia** there is a reference to comet observations made by a "Mr. Arthur Storer, at the river Patuxent, near Hunting Creek, in Maryland, in the confines of Virginia . . ."? Then Newton enters upon some speculations and deductions concerning comets and their experience in passing close to the sun. Not all of his ideas still hold in the light of subsequent investigation, but he does consider the formation of tails of comets by light pressure. One important aspect of the role of comets in the development of science is not always recognized. Because of their eccentric orbits, they provided the evidence which proved to be a strong wedge in dislodging the then current theory of vortices in favor of Newton's law of gravitation.

PAUL HERGET
University of Cincinnati Observatory

The INDEX for Volume V

is now ready for mailing. Its style is similar to previous indexes, including title page; author, title, subject, and topic references. Send 35 cents in stamps or coin, or include it with your subscription renewal check or money order. Indexes to earlier volumes are also available.

SKY PUBLISHING CORPORATION

NEW BOOKS RECEIVED

SCIENCE SINCE 1500, *H. T. Pledge*, 1947, *Philosophical Library*. 357 pages. $5.00.

A short history of mathematics, physics, chemistry, and biology during the past four and one half centuries, written by the librarian of the Science Museum of London.

AN ALBUM OF CELESTIAL PHOTOGRAPHS, *A. L. Bedell*, 1946, *Bedell*. Unpaged. $1.50.

A group of 65 astronomical photographs photo-offset with captions together in the front of the book; there is a moon map in the back of the book.

SCIENCE, *D. W. Hill*, 1946, *Chemical*. 114 pages. $2.75.

A series of essays discussing the application of science and its products to man's activities: industry, politics, war, education, religion, and leadership.

HARVARD COLLEGE OBSERVATORY, THE FIRST CENTURY, 1946, *Harvard College Observatory*. 94 pages, paper-bound. $1.00.

On the occasion of Harvard's first astronomical centennial, this booklet describes briefly some of the major accomplishments at Cambridge and the several Harvard observing stations. In addition to the introduction, there are 10 short, well-illustrated chapters, covering in turn the first hundred years, instruments, stellar brightnesses, the Milky Way, classification of spectra, variable stars, galaxies and globular clusters, solar astronomy, astrophysics, and meteor photography, all as related to the past, present, and future of Harvard astronomy. (This booklet may be ordered directly for $1.00 postpaid from Harvard College Observatory, 60 Garden St., Cambridge 38, Mass.)

Planetarium Notes

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STAFF: *Director*, Wagner Schlesinger. *Other lecturer:* Harry S. Everett.

February: EXPLORING THE UNIVERSE. A survey of the structure and extent of the observable universe, and of the principal types of objects of which the universe is made up.

March: PAST AND FUTURE SKIES.

BUHL PLANETARIUM

Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300

SCHEDULE: Mondays through Saturdays, 3 and 8:30 p.m.; Sundays and holidays, 3, 4, and 8:30 p.m.

STAFF: *Director*, Arthur L. Draper. *Other lecturers:* Nicholas E. Wagman, J. Frederick Kunze.

February: OUR PLANET NEIGHBORS. The story of the other worlds of our solar system, their curious motions in the heavens and the possibility of life upon them.

March: APOLLO AND THE MUSES, and AROUND THE WORLD IN 50 MINUTES.

FELS PLANETARIUM

20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Rittenhouse 3050

SCHEDULE: 3 and 8:30 p.m. daily; also 4 p.m. on Saturdays, Sundays, and holidays. 11 a.m. Saturdays, Children's Hour (adults admitted).

STAFF: *Director*, Roy K. Marshall. *Other lecturers:* I. M. Levitt, William L. Fisher, Armand N. Spitz, Robert W. Neathery.

February: TO THE SOUTH POLE. Revival of interest in the last unexplored continent prompts us to travel southward to see the skies there. Dramatic episodes in explorations of the past will be included.

March: LIFE ON OTHER WORLDS.

GRIFFITH PLANETARIUM

P. O. Box 9866, Los Feliz Station, Los Angeles 27, Cal., Olympia 1191

SCHEDULE: Wednesday and Thursday at 8:30 p.m. Friday, Saturday, and Sunday at 3 and 8:30 p.m. Extra show on Sunday at 4:15 p.m.

STAFF: *Director*, Dinsmore Alter. *Other lecturers:* C. H. Cleminshaw, George W. Bunton.

February: A JOURNEY THRU TIME. Reproduction of the heavens as seen during thousands of years shows the changes resulting from the earth's slow wobbling called precession.

March: THE SEASONS.

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STAFF: *Honorary Curator*, Clyde Fisher. *Chairman and Curator*, Gordon A. Atwater. *Other lecturers:* Robert R. Coles, Catharine E. Barry, Shirley I. Gale, Edward H. Preston.

February: OUTPOSTS OF THE HEAVENS. A survey of those objects that lie buried in the remote depths of interstellar space will be made this month.

March: SEVEN WONDERS OF THE UNIVERSE.

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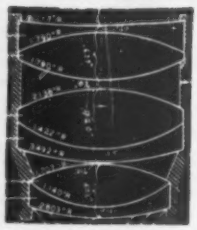

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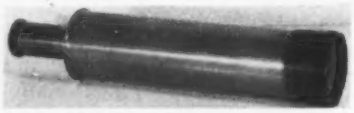

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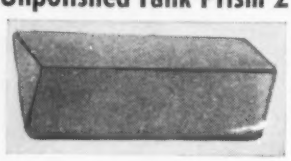

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THIS DESCRIPTION of a low-power telescope I have devised for solar and general observing is sent at the suggestion of Neal J. Heines, chairman of the Solar Division of the American Association of Variable Star Observers, by a new recruit to the job of keeping track of activity on the sun. The instrument is built around a 3-inch coated achromat sold last year as Army surplus. Our laboratory bought a hundred of these for 10 dollars each with the expectation of building up terrestrial telescopes as a sparetime job. We have had no spare time up to date!

As a personal experiment, I found one of these lenses to be of excellent quality for rich-field use. For many years I have adhered to the principle that how much you see is not as important as how well you see it and that observing while suffering sharp pains in the neck and lower parts of the spine is not conducive to good seeing. That is why the instrument takes the form it does.

The mounting is an equatorial fork with the eyepiece on the declination axis, two inches from the right-angle prism. Thus the eyepiece swings around a semicircle only four inches in diameter and the viewing position, each side of the meridian, varies from straight down to horizontal. A comfortable and relaxed sitting position on an ordinary camp stool is a natural observing position, so that continued observing is a pleasure rather than a chore.

The polar axis is mounted on ball bearings and has a 128/1 slow motion. This is not a worm, but a four-inch spur gear operated smoothly with a screw of appropriate pitch. A cork-l'ned slipping clutch allows quick movement of this axis. There is an hour-angle circle and a slip-ring 24-hour clock dial which is handy for keeping sidereal time with reference to a

George R. Warren, of West Chester, Pa., demonstrates the ease of observing with his 3-inch solar telescope.

GLEANINGS is always ready to receive reports and pictures of amateur instruments and devices, and is open for comments, contributions, and questions from its readers.

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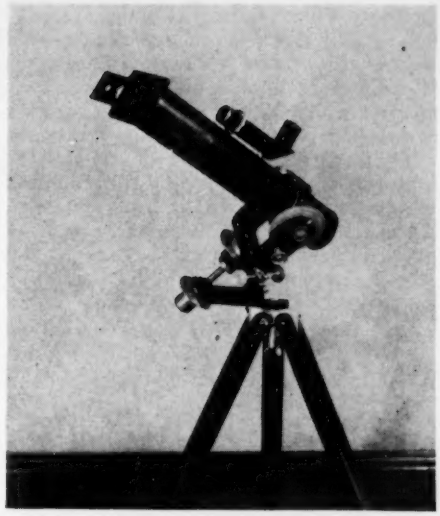
given star all evening. The declination axis has an 18/1 slow motion and slipping clutch.

A brass box at the junction of the axes carries the trunnions and eyepiece as well as the prism, sun filter, and a polariscope. The center of gravity of the instrument is exactly over the apex of the very rugged tripod. All the moving parts are carefully counterbalanced.

A synchronous clock drives the polar axis in sun time. This works on 10 volts from a transformer and is not to be regarded as a luxury. It is very convenient to have the sun stand still while searching for faint spots.

The prism is of 1¼-inch face and coated. The sun filter is of WW-10 welding helmet glass. The polariscope is of two polaroid disks, one rotating through 90 degrees. The eyepieces are a 1¼-inch Zeiss Kellner, a 1-inch Zeiss Kellner, a ¾-inch B. & L. symmetrical achromat, a ½-inch Ramsden, and a 40-power compound microscope. I have a camera which screws on the ¾-inch eyepiece and takes 2¼ x 3¼ cut film with a Kodak shutter. This has been used only on the moon at present and requires 1/10 second with super-speed film. For photography, the achromatic visual lens should be combined with a yellow filter, but I have not gone into this problem yet.

The dew cap takes the form of a diaphragm which is one-half inch, one inch, two inches, or of full aperture. The smaller openings are for warming up on a cold day — full aperture once cracked the filter in cold weather.



Mr. Warren's telescope in another position to show the right ascension and declination circles, support of the polar axis, and "dew cap" carrying an adjustable diaphragm mechanism.

The ½-inch Ramsden eyepiece was rebuilt into a fine focusing mount with a crosshair reticle to indicate the meridian and equator of the sun. A professional glass reticle gave trouble with dust specks appearing as wandering sunspots. In its place was mounted a cell with No. 40 gauge wire crosshairs. This was placed

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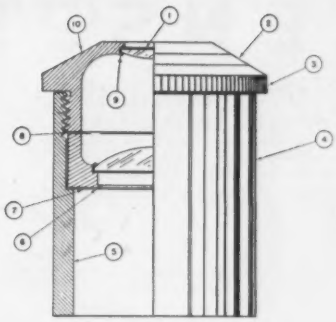

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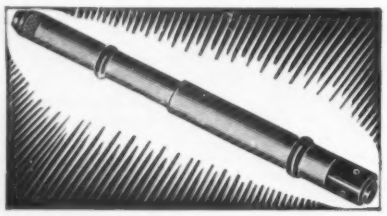

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29 mm Dia.	76 mm F.L.	ea.	1.25
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just out of focus so that, while the indication is still there, the image can be seen through the "hairs." This eyepiece combination gives a power of 32 and just takes in the full disk of the sun. The definition is excellent with good seeing conditions.

The construction is a mixture of steel, brass, bakelite, and wood. It is entirely weatherproof, in fact it lives outdoors. All metal parts are cadmium plated or painted black. It wears a heavy cellophane nightshirt when not in actual use, which keeps it remarkably clean.

GEORGE R. WARREN
R. D. 2, West Chester, Pa.

ARTICLES ON ASPHERICAL AND OFF-AXIS SURFACES

TWO ARTICLES appearing recently in the **Journal** of the Optical Society of America may be of interest to some of our more mathematically inclined readers. The abstracts are quoted.

"The Calculation of Aspherical Correcting Surfaces," by M. Herzberger and H O. Hoadley, Vol. 36, page 334, June, 1946. A straightforward and reasonably quick method is described for the calculation of the aspherical correcting surface of the Schmidt camera, or other optical system in which the aspherical surface is adjacent to the object or image. An extension of the method is also described for cases where the correcting surface is in the interior of the system, and the rays must be refracted to match a given non-spherical wave surface, instead of meeting at a point.

"Quantitative Tests for Off-Axis Parabolic Mirrors," by L. G. Schulz, Vol. 36, page 588, October, 1946. Quantitative methods for examining and describing the surfaces of off-axis parabolic mirrors are given, together with practical suggestions for the most effective use of such mirrors. Included are tests with, and without, an optical flat. In each case, the theory and experimental procedure are illustrated by application to a particular mirror.

AMERICAN ASTRONOMERS REPORT

(Continued from page 15)

grams, with results which demonstrate the fact that aircraft can be used with success to carry out a scientific eclipse program. Both clouds and excessive absorption in the earth's lower atmosphere are successfully avoided by airplane observing stations.

The intensity distribution in the coronal spectrum has been measured and compared with that of the full moon photographed with the same cameras. Preliminary measures indicate that in the range from 4000 to 6000 angstroms the intensity of the continuous coronal spectrum averages roughly one quarter that of the full moon, but the coronal spectrum is bluer, with a color temperature of about 6,000 degrees or possibly higher. Dr. Millman also presented other details of his measures.

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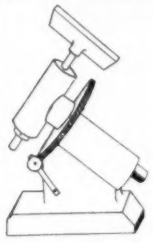

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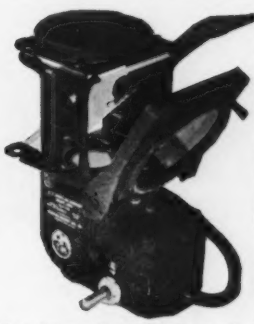

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OBSERVER'S PAGE

Greenwich civil time is used unless otherwise noted.

GIACOBINID METEOR REPORTS

Oscar E. Monnig, in the Texas Observers' **Bulletin** for November, gives a resume of the Giacobinid meteor shower in October as gleaned from a preliminary survey of "a mass of information and reports." He brings out the following principal points:

The maximum came in the quarter hour of 9:45 to 10:00 p.m. CST, some results placing it at 9:50, others at 9:55. The entire shower, at least after maximum, was much shorter than the anticipated 28 hours — more likely under half that period. The maximum was sharp and short and the meteors fell off more rapidly than they had increased.

The shower was brighter than expected, with bright meteors quite common. A single observer probably saw not more than 20 per cent of all the meteors in his sky, which gives about 9,000 to 30,000 per hour for a period of about five minutes or so at maximum. This is the same general order of rates as reported for Leonid showers at their best.

The meteors were in groups — not uniform in distribution — possibly there were pulses or waves in irregular periods sometimes a few minutes, sometimes only a few seconds long. Terminal flares and minor bursts were frequently observed. Variations from straight paths were also reported. As expected, the radiant was not a point.

COMETS BESTER AND JONES

Harvard Announcement Cards give the predicted positions of two comets which are now moving northward and bright enough to be found by amateur observers. Comet Bester has turned out to be about two magnitudes brighter than expected, and during February should be of magnitude 9.5 or brighter. Comet Jones will be of about the 10th magnitude.

On January 31st, Comet Bester is at $1^h\ 20^m.4$, $-4°\ 52'$; on the 8th of February at 1:18.4, $-1°\ 44'$; 16th at 1:17.8, $+1°\ 11'$; 24th at 1:18.2, $+3°\ 57'$; on March 4th at 1:19.6, $+6°\ 34'$.

Positions for Comet Jones are: Jan. 31, 18:34.0, $-1°\ 06'$; Feb. 8, 18:48.7, $+1°\ 50'$; 16, 19:02.2, $+4°\ 48'$; 24, 19:14.7, $+7°\ 49'$; March 4, 19:25.9, $+10°\ 51'$.

These ephemerides have been computed by Dr. L. E. Cunningham, Students' Observatory, University of California at Berkeley.

DECEMBER OBSERVATIONS

Unfortunately the eclipse of the moon of December 8th was clouded out here. For the first 10 days of the month the sky was completely overcast; now for the past week skies have been beautiful. Saturday last I observed the Geminid meteors for two hours and plotted 21 per hour. Also, the other night I saw the Small Magellanic Cloud, quite low but distinct.

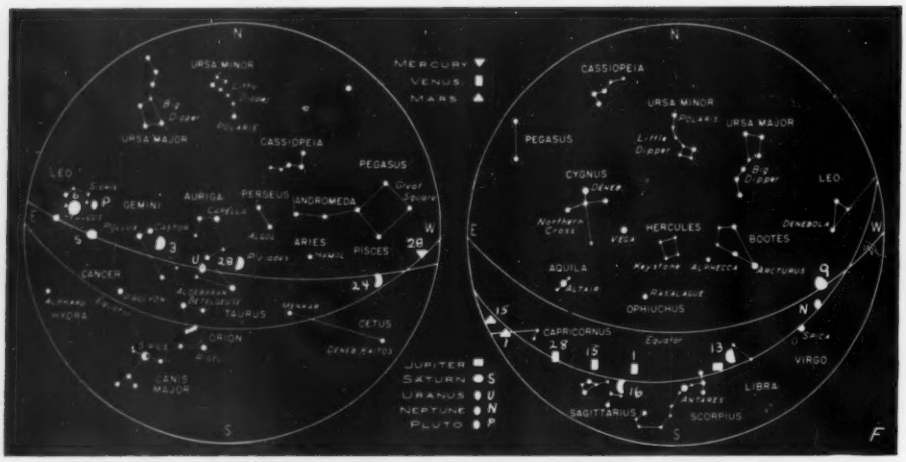
EDWARD ORAVEC
Guam

On December 15th, it was possible to pick up Venus by eye at about 9:30 a.m. by looking south from Waterbury, and at an elevation of about 30°. A 4-inch refractor with a 25-power eyepiece showed the crescent phase very nicely. It was impossible to detect Jupiter despite the fact that it must have been in the same three-degree field of the eyepiece.

On December 28th, Venus was located at noon with 7x binoculars at about 45° above the southern horizon from Palm Beach, Fla. Once located by binocular, it was possible to see Venus by naked eye. With a power of 45x on a 3-inch refractor, Venus was taken by the uninitiated for the moon about five days old. Once again a careful search in the vicinity of Venus failed to show Jupiter. Presumably this was because its brightness per unit area was not as great as the brightness of the sky in front of and surrounding the planet.

D. W. ROSEBRUGH
Waterbury, Conn.

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 7:30 a.m. local time on the 7th of the month, and at 6:30 a.m. on the 23rd. At the left is the sky for 7:30 p.m. on the 7th and 6:30 p.m. on the 23rd. The moon is shown for certain dates by symbols which give roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury reaches a favorable elongation this month, and is visible in the evening sky starting early in the month. On February 10th, it will appear as a star of -1.0 magnitude, easily seen a half hour after sunset. By greatest elongation on the 21st, Mercury will have diminished in brightness to -0.3, and will set 1½ hours after sunset although it will be only 18° east of the sun.

Venus continues to dominate the morning sky with its brilliance. It will decrease in brightness very slowly until superior conjunction with the sun next autumn. It now rises about three hours ahead of the sun, and during February will traverse the entire constellation of Sagittarius.

Mars is too near the sun to be seen.

Jupiter. This planet now equals the brightness of Sirius, and is situated about 5° west of Beta Scorpii. It rises about 1:00 a.m., local time, and on the morning of the 13th the moon will be just below it upon rising.

Saturn, bringing brilliance to otherwise inconspicuous Cancer, can be seen practically all night. Its motion is retrograde, and it is of zero magnitude.

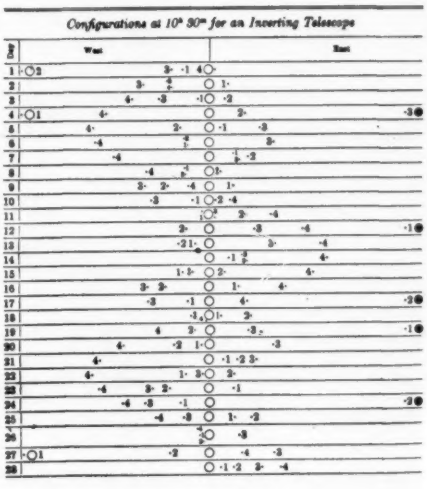
Uranus remains about stationary all month in eastern Taurus, at $5^h\ 07^m$, $+22°\ 59'$ on the 15th.

Neptune rises about three hours after sunset and can be found with the aid of a small telescope, close to Gamma Virginis. Its position on the 15th is $12^h\ 41^m$, $-2°\ 45'$.

E. O.

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the GCT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the American Ephemeris and Nautical Almanac.



OCCULTATIONS FOR FEBRUARY

For selected occultations (visible at three or more stations in the U. S. and Canada under fairly favorable conditions), these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, limiting parallels of latitude, immersion or emersion; standard station designation, GCT, a and b quantities in minutes, position angle; the same data for each standard station westward.

Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5	**E** +91°.0, +40°.0
B +73°.6, +45°.6	**F** +98°.0, +30°.0
C +77°.1, +38°.9	**G** +114°.0, +50°.9
D +79°.4, +43°.7	**H** +120°.0, +36°.0
	I +123°.1, +49°.5

The a and b quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. Lo, lat. L) within 200 or 300 miles of a standard station (long. LoS, lat. LS). Multiply a by the difference in longitude (Lo — LoS), and multiply b by the difference in latitude (L — LS), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Greenwich civil time to your own standard time.

For additional occultations consult the American Ephemeris and Nautical Almanac and the British Nautical Almanac, from which these predictions are taken. Texas predictions were computed by E. W. Woolard and Paul Herget.

February 1-2 **121 Tauri** 5.3, 5:32.2 +24-00.4, 11, +77° +5° Im: **A** 3:35.0 −1.3 −2.9 131°; **B** 3:26.4 −1.4 −2.0 118°; **C** 3:46.0 ... ... 160°; **D** 3:21.4 −1.7 −2.6 127°; **E** 3:11.0 ... ... 146°; **G** 2:20.8 −1.1 +1.2 79°; **H** 2:01.7 −2.0 −0.2 116°; **I** 2:09.5 −0.9 +1.5 73°.

2-3 **Epsilon Geminorum** 3.2, 6:40.7 +25-11.1, 12, +70° +7° Im: **A** 4:42.3 −1.3 −1.5 111°; **B** 4:36.8 −1.3 −1.2 101°; **C** 4:42.8 −1.3 −2.8 128°; **D** 4:30.8 −1.5 −1.4 111°; **E** 4:18.1 −1.8 −2.2 131°; **G** 3:35.3 −1.2 +1.0 83°; **H** 3:22.4 −2.2 −1.1 130°; **I** 3:23.6 −1.0 +1.3 81°. Em: **A** 5:50.1 −1.2 −0.8 261°; **B** 5:46.0 −1.1 −1.1 269°; **C** 5:45.1 −1.7 +0.1 244°; **D** 5:40.3 −1.4 −0.5 258°; **E** 5:19.0 −2.1 +1.2 234°; **G** 4:46.4 −1.4 +0.3 270°; **H** 4:14.3 −1.2 +3.4 217°; **I** 4:33.0 −1.4 +0.7 269°.

3-4 **Kappa Geminorum** 3.7, 7:41.2 +24-31.6, 13, +68° 0° Im: **A** 1:30.9 −1.6 −0.2 115°; **B** 1:29.7 −1.4 +0.4 104°; **C** 1:24.7 −1.7 −0.6 126°; **D** 1:20.8 −1.3 +0.4 108°; **E** 1:05.0 −1.1 +0.5 109°; **F** 0:57.5 −1.5 −1.0 138°; **G** 1:10.6 +0.1 +2.2 55°; **H** 0:46.9 0.0 +1.1 86°; **I** 1:09.7 +0.4 +2.2 47°. Em: **A** 2:41.0 −1.8 +1.1 254°; **C** 2:27.6 −1.7 +2.0 240°; **E** 2:09.6 −1.2 +1.6 252°; **F** 1:40.3 −0.3 +3.2 219°; **H** 1:42.6 −0.3 +1.1 269°.

7-8 **Nu Virginis** 4.2, 11:43.1 +6-49.6, 17, +61° −23° Em: **A** 5:44.1 −1.2 −1.0 316°; **B** 5:39.8 −1.0 −1.1 325°; **C** 5:40.3 −1.5 −0.3 299°; **D** 5:35.2 −1.1 −0.6 312°; **E** 5:21.9 −1.1 +0.4 290°; **F** 4:59.1 −1.3 +3.2 241°; **G** 5:08.7 −0.3 −0.1 321°.

9-10 **1 Virginis** 4.8, 13:29.2 −6-00.0, 19, +78° −11° Em: **C** 11:19.5 +0.2 −3.8 8°; **D** 11:02.6 ... ... 16°; **E** 11:10.7 −0.9 −2.2 340°; **F** 11:19.4 −1.9 −1.5 306°; **G** 10:33.1 −0.9 −0.8 324°; **H** 10:28.7 −2.2 +0.5 276°; **I** 10:25.2 −1.0 −0.2 309°.

11-12 **Nu Librae** 5.3, 15:03.7 −16-03.2, 21, +74° −6° Em: **A** 11:34.5 −0.8 −2.4 349°; **C** 11:37.6 −1.3 −2.0 335°; **D** 11:25.9 −1.0 −1.8 340°; **E** 11:16.7 −1.5 −1.0 315°; **F** 11:08.3 −2.6 0.0 280°; **G** 10:46.1 −0.9 +0.4 303°; **H** 10:22.2 −2.3 +2.7 248°; **I** 10:37.5 −0.8 +0.9 288°.

12-13 **Lambda Librae** 5.1, 15:50.2 −20-00.6, 22, +70° +2° Em: **A** 10:41.2 −1.7 −0.4 300°; **B** 10:38.3 −1.5 −0.4 303°; **C** 10:33.6 −2.0 0.0 287°; **D** 10:29.3 −1.7 0.0 292°; **E** 10:06.0 −2.0 +1.3 265°.

27-28 **Omega Tauri** 4.8, 4:14.2 +20-27.0, 7, +90° +5° Im: **A** 4:07.3 +0.5 −3.5 139°; **B** 3:58.4 +0.1 −2.7 126°; **D** 4:05.5 +0.4 −4.3 144°; **G** 3:16.8 −1.5 −2.6 121°; **I** 3:05.1 −1.9 −2.6 123°.

27-28 **53 Tauri** 5.4, 4:16.3 +21-00.9, 7, +55° −18° Im: **A** 5:14.6 −1.4 +3.1 8°; **C** 5:06.9 −0.5 +0.5 38°; **D** 5:09.8 −1.0 +1.7 18°; **E** 4:59.1 −0.7 0.0 50°; **F** 4:59.6 −0.6 −1.0 91°; **G** 4:43.6 −1.2 +2.1 20°; **H** 4:29.7 −1.6 −0.6 82°; **I** 4:29.9 −1.3 +1.6 30°.

March 2-3 **A Geminorum** 5.1, 7:20.2 +25-09.3, 10, +65° 0° Im: **A** 3:18.4 −1.5 −1.0 96°; **B** 3:14.4 −1.6 −0.6 88°; **C** 3:15.7 −1.6 −1.5 112°; **D** 3:06.3 −1.6 −0.8 98°; **E** 2:49.7 −1.9 −1.3 118°; **G** 2:13.4 −1.2 +1.4 77°; **H** 1:56.3 −1.8 −0.5 123°.

PHASES OF THE MOON

Full moon	February	5, 15:50
Last quarter	February	12, 21:58
New moon	February	21, 2:00
First quarter	February	28, 9:12
Full moon	March	7, 3:15

MINIMA OF ALGOL

February 3, 1:33; 5, 22:23; 8, 19:12; 11, 16:01; 14, 12:51; 17, 9:40; 20, 6:29; 23, 3:19; 26, 0:08; 28, 20:57. March 3, 17:47; 6, 14:36.

VARIABLE STAR MAXIMA

These predictions of variable star maxima are made by Leon Campbell, recorder of the AAVSO, Harvard College Observatory, Cambridge 38, Mass. Serious-minded observers interested in making regular telescopic observations of variable stars may write to Mr. Campbell for further information.

Only stars are included here whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0 Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

February 2, S Canis Minoris, 7.5, 072708; 8, R Centauri, 5.9, 140959; 9, S Hydrae, 7.9, 084803; 11, R Normae, 7.2, 152849; 12, SS Virginis, 6.9, 122001; 12, R Phoenicis, 7.8, 235150; 13, R Reticuli, 7.7, 043263; 15, R Geminorum, 7.1, 070122a; 16, S Ursae Majoris, 7.9, 123961; 17, R Bootis, 7.3, 143227; 18, T Aquarii, 7.9, 204405; 24, RT Cygni, 7.4, 194048. March 6, S Carinae, 5.7, 100661; 6, X Centauri, 7.8, 114441.

The irregular variable, R Coronae Borealis, 154428, began a rapid and deep decrease in light early in November, reaching magnitude 11.3 by the 21st of that month, a drop of more than five magnitudes. SS Cygni, 213843, was observed on the rise to maximum on November 22nd, 80 days after the previous rise. U Geminorum, 074922, passed through a broad maximum about October 1st.

GREENWICH CIVIL TIME (GCT)

TIMES used on the Observer's Page are Greenwich civil or universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the GCT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

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Classified advertisements are accepted for this column at 40 cents a line per insertion, six words to the line. Minimum ad is three lines. Remittance must accompany orders. Address Ad Dept., Sky and Telescope, Harvard Observatory, Cambridge 38, Mass.

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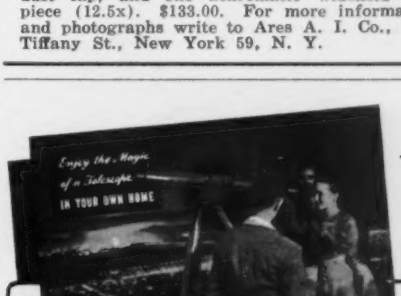

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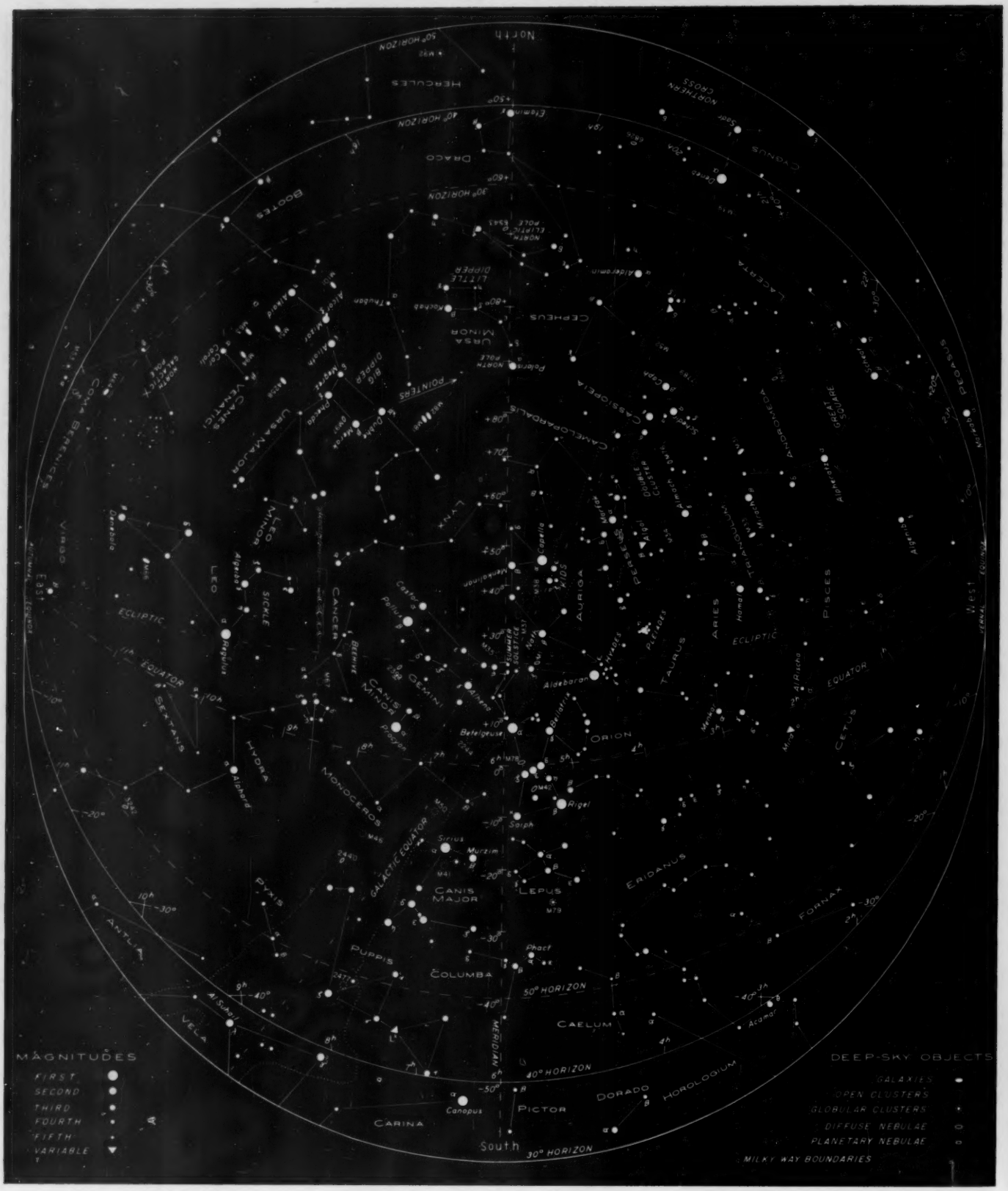


DEEP-SKY WONDERS

CONTINUING the survey of the Taurus-Auriga region we find three galactic clusters:

NGC 1647, 8^8, $4^h\ 43^m$, +19° 18′; large, thin, lacking in faint stars, 53′ diameter, about 40 stars. It is located visually in a vacant region, nevertheless Ross photographs show a background of bright and dark nebulosity.

NGC 1746, 21^7, $5^h\ 00^m$, +24° 30′; 54′ in diameter, and over 500 stars with the brighter objects well above NGC 1647 in magnitude, but the cluster is so irregular that it may not always be recognized as such when sweeping. It is said to contain an unusual number of **K** stars, possibly explaining its relative lack of luster on the Ross photos.

NGC 1817, 7^4, $5^h\ 09^m$, +16° 25′; a smaller cluster near the Orion border, but more certainly noticed than the preceding objects. In a 13-inch telescope it is a fine object, although a 6-inch rich-field reveals its character.

WALTER SCOTT HOUSTON

STARS FOR FEBRUARY

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

EVENING STARS FOR SOUTHERN OBSERVERS

THIS CHART is prepared for a basic latitude of 30° south, but it may be used conveniently by observers 20 degrees on either side of that parallel. These southern charts appear in alternate months, but always two or three months in advance, to allow time for transmission to observers in any part of the world. The sky is here shown as it appears on April 7th at 11 p.m., April 23rd at 10 p.m., May 7th and 23rd at 9 p.m. and 8 p.m., respectively. Times for other days vary similarly, four minutes earlier per day. These are local mean times which must be corrected for standard time differences. The 30° horizon is a solid circle; the other horizons are circles, too, those for 20° and 40° south being dashed in part. When facing south, hold "South" at the bottom, and similarly for other directions. Observers in the tropics may find north circumpolar stars on any of our northern star charts. For other charts in this series, see issues of alternate months, April, 1945, to June, 1945; September, 1945, to July, 1946; and August, 1946, to the present.

In Focus

CONTINUING NORTHWARD from the region shown last month, the current back cover shows an interesting portion of the moon, combining a rugged and pitted section with some smooth "sea" formations and apparently filled-in regions. Reference may be made to Plates IV, V, VI, and X, which overlap this area, and to the In Focus items in the May, June, and July issues last year, and in January.

All named features in this region are sketched on the key chart, and descriptions of some of these appear below. Spellings follow the International Astronomical Union's **Named Lunar Formations**, by Blagg and Mueller, and biographical information is from the British Astronomical Association's **Who's Who in the Moon.**

Alpetragius. A crater with high surrounding walls, and a central mountain; the illumination at this phase is especially interesting.

Alphonsus. Alfonso X (1223-1284) was a king of Castile, for whom the **Alphonsine Tables** were named. Drawn up by astronomers gathered at Toledo at his request, and published in 1252, these tables contained data on the planets, eclipses, astronomical constants, and so on, which were standard throughout Europe for the succeeding 300 years. On the moon this is a large walled plain, with walls in part 15 miles thick at the base.

Arzachel. The second of three large plains which lie on the meridian of the moon. North of it are Alphonsus and Ptolemaeus. Its walls are as much as 13,000 feet high, and there are interior craters and hills.

Blanchinus. A walled plain; its interior is depressed more than 10,000 feet below its walls. Named for G. Bianchini, a 15th-century Italian astronomer.

Chladni. A small, round crater just on the edge of Sinus Medii. Named for a German physicist, some of whose work on sound led to the discovery of Chladni's figures. He also was the first to show that meteorites are of extraterrestrial origin.

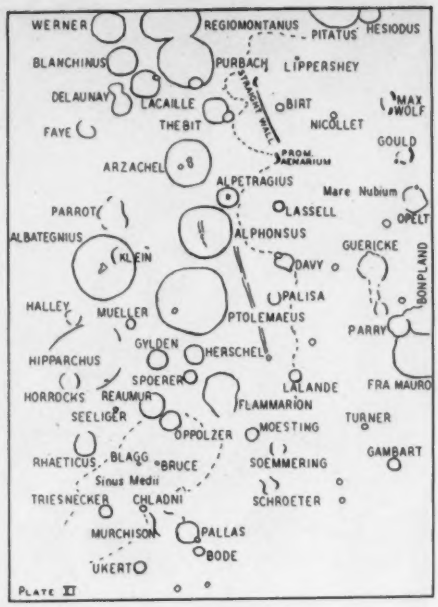
Delaunay. This interesting crater is divided nearly into two parts by a large ridge. The formation was named by Birt for a French astronomer who was also a student of the moon.

Faye. A ringed plain about 20 miles across, named for a 19th-century French astronomer chiefly remembered as the discoverer of Faye's comet.

Flammarion. Camille Flammarion (1842-1925) was a French astronomer, widely known to recent generations of amateurs as a popularizer of the subject, and author of numerous books. On the moon, this feature is about 40 miles in diameter, and Goodacre says "its original walls seem to have been more or less destroyed by the erosive action of lava, when the Sinus Medii was forming." A cleft runs across near its northern edge and continues toward Lalande.

Herschel. Named for William Herschel (1738-1822), brilliant astronomer who was trained as a musician, but combined astronomy and music. He made and used excellent telescopes, observed and catalogued vast numbers of stars and nebulae, discovered Uranus, investigated the form of the galaxy. His sister, Caroline, and son, John, are also represented on the moon. The crater has terraced walls and an interior mountain, invisible under this illumination.

Lacaille. A ringed plain about 40 miles wide, named for Nicholas Louis de la Caille (1713-1762). He worked under Cassini at the Paris Observatory and on geodetic surveys; later became professor at the Collège Mazarin. From the Cape he catalogued and mapped the southern sky, and named several new constellations. He measured an arc of the meridian at the Cape, the first to be done so far south, and made observations of the moon for determination with Lalande of the lunar parallax.



Lalande. A crater on Mare Nubium whose interior is about 6,000 feet below the surrounding plain. A long valley on the southwest extends more than 130 miles, ending near the walls of Alphonsus. A French astronomer, somewhat younger than Lacaille, Lalande became director of the Paris Observatory. When only 19, he had been sent to Berlin to make measurements of the moon for comparison with those of Lacaille.

Lippershey. One of the smallest named craters on the moon, a little over four miles in diameter, named for Hans Lippershey, Dutch spectacle maker who invented the telescope and applied for a patent on it late in 1608.

Ptolemaeus. The largest of the three "meridional ring plains," and one of the best observed regions on the moon. Claudius Ptolemaeus, c. 130 A.D., was the last of the great Greek astronomers, deviser of the Ptolemaic system of the planets, and author of the **Almagest,** a summary of earlier work. His influence on astronomy endured for 14 centuries.

Purbach. A massive formation with irregular walls, and considerable detail in its interior — craters, hills, and ridges. Georg von Peuerbach was a 15th-century Bavarian astronomer, teacher of Regiomontanus.

Rhaeticus. A cleft runs from outside this feature in the direction of Reaumur. Rhaeticus itself has irregular and broken walls. Named for Georg Joachim Rhaeticus, whose birthplace of Rhaetia gave him his Latin surname. He is chiefly famous for bringing about the publication of Copernicus' **De Revolutionibus,** and had already written three years earlier an account of the Copernican system, the **Prima Narratio.**

Thebit. This crater has a smaller, apparently newer one in its eastern wall, which in turn has a crater to the east of it. The floor of Thebit is very rough.

Werner. Although at this phase the floor is dark, there are actually a number of interior details. Werner's walls on the east side are said to be 16,000 feet high.

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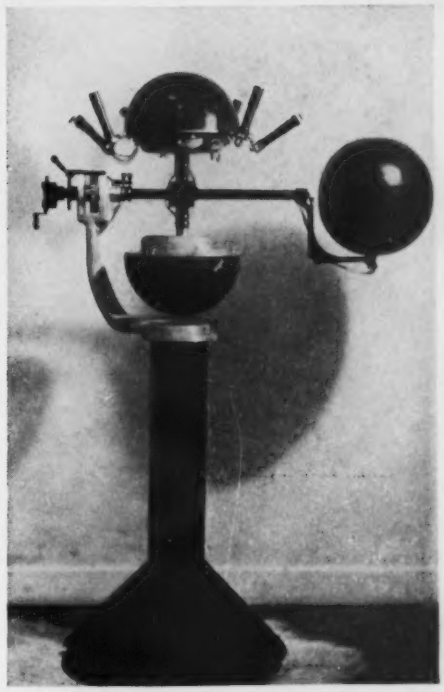

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